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Meßsysteme
GmbH

imc WAVE

Workstation for Acoustic and Vibration Engineering

User's Manual Configuration Software

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imc WAVE works in a graphical environment called Microsoft Windows which is produced by Microsoft Corporation. Microsoft Windows provides a standardized user interface for imc-Devices software and all other Windows-applications.

The imc-Devices product package includes the software needed to operate imc WAVE.

Microsoft-Windows offers the following advantages:

Running multiple applications:

Multiple applications can be run under Windows at the same time, and the user can easily switch from one to the other. This provides an integrated working environment.

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Data transfer between applications:

Data can be exchanged between imc WAVE and other Windows-applications.

Windows-control of DOS environment:

From the Windows-environment, you have easy access to all Windows and DOS applications, files, folders and drives. All MS-DOS functions (such as file management and diskette formatting) can be controlled from Windows.

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Although graphically oriented programs such as imc WAVE are designed to be used intuitively, we recommend reading through the user's manual. You'll discover interesting functions, many of which you may previously not have been aware of.

The technical specifications stated in these chapters are valid for 1 year from the device's delivery date and for use under normal operating conditions. Note in particular the ambient temperatures specified.

Symbols displayed on the equipment

CAUTION! REFER TO THE USER'S MANUAL.

This symbol advises the user to consult the User's Manual for more information concerning possible dangers.

DANGER: HIGH VOLTAGE1

This symbol is used anywhere on the device where a high-voltage danger exists. Only trained maintenance personnel may perform repairs to any of these areas.

DANGER OF ELECTROSTATIC DISCHARGE

Electrostatic sensitive devices, that is any electronic components at risk of damage due to electrostatic discharge (ESD), are denoted by this symbol.

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ESD WARNING!
Despite protective measures, our components are sensitive to electrostatic discharge. Electrostatic charge may build up unnoticed and may even cause damage without your being immediately aware of it. Such damage can be avoided by carrying out all work at "safe" work stations and by utilizing packaging with electrostatic shielding when transporting sensitive components.
Always follow ESD precautions!

ATTENTION!

- When handling static-sensitive devices, observe the following guidelines:
- Always statically discharge yourself (e.g. by touching a grounded object) before handling static-sensitive devices.
- Any equipment and tools used must also be free from static charge.
- Unplug the power cord before removing or inserting static-sensitive devices.
- Handle static-sensitive devices by their edges.
- Never touch a connection pin or conducting track on static-sensitive devices.

Always ensure that electrostatic charge does not form at contacts between device sockets and their leads. Any charge which may develop here is to be drained off. Damage resulting from ESD is not covered in the guarantee.

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Hardware Requirements

Minimum required hardware configuration:

- IBM - (100%-compatible) AT with Pentium processor
- hard drive with min. 100 MByte free memory plus memory requirements of MS - Windows
- DC-ROM drive (for installation)
- graphics card supported by MS - Windows with 800x600 pixels and matching monitor
- AT-keyboard
- 32 MByte RAM
- mouse (bus or serial) supported by MS - Windows, Microsoft-mouse or compatible mouse, Logimouse (many MS-Windows functions work easier and faster through the use of a mouse)

We recommend:

- upgrade to 128 MByte RAM or more
- processor: Pentium 3 –500 (or compatible) or higher, to guarantee rapid display of high data volume
- graphics card with 1024 x 768 pixels at 65000 colors and a refresh rate from 70 Hz on

Additional options

- MS - Windows supported printer (almost all printers)

Software requirements and restrictions

The following prerequisites are required to run imc WAVE:

- 32-Bit Windows (Windows 2000, Windows XP)

We do not guarantee that the software will run under any future version of these operating systems.

Memory management

It is well known Microsoft Windows allows *"multitasking"*, that is, several programs can be loaded to memory and run at once. In actual fact, however, the computer can only run any *one* application at a given moment. But, as far as the user is concerned, several applications are *available* and can be run *virtually* in parallel.
The imc WAVE software is designed with true multitasking in mind, that is, its program code has been divided into many smaller segments. However, imc WAVE also uses RAM to store its waveform data, and when a lot of data are present, this can consume all of the available memory. It is thus not recommended to run many programs at once.
imc WAVE retains data in RAM as long as there is sufficient space there. Otherwise imc WAVE stores its data on the available drives (disks). The default folder is the environmental variable "Temp" or "Tmp" under Windows.

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2 Introduction

The imc **W**orkstation for **A**coustic and **V**ibration **E**ngineering (referred to below as imc WAVE) is an application adapted to the requirements of sound and vibration measurement engineering. Different analyzing tools are dedicated to each of the areas of this field, for instance:

- FFT-Analyzer
- Sound power
- Order analysis

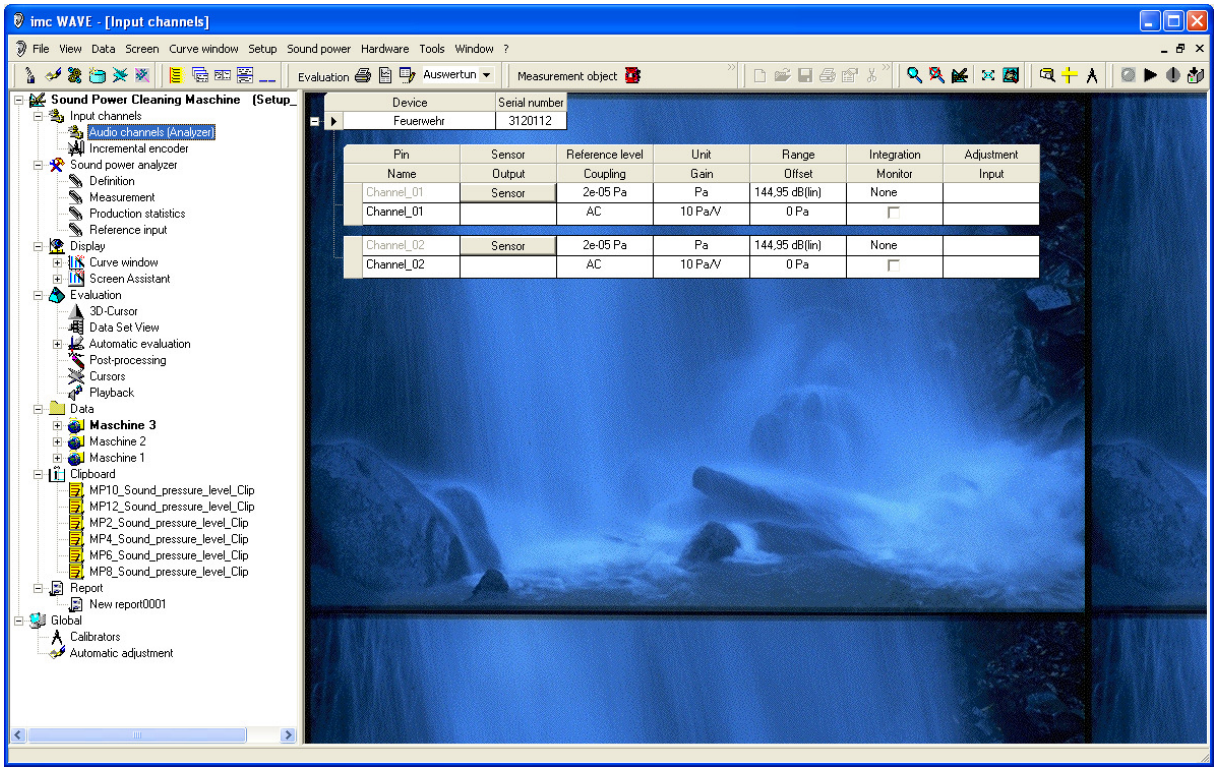

Fig. 1: imc WAVE user interface

imc WAVE is project-oriented and provides the user with a simple operating interface. A project is begun by selecting an analyzer. This analyzer presents a window as a table offering settings. There are additional windows used by all the analyzers in common, such as trigger settings, connection configuration, curve window etc.
To navigate within a project, the Project Explorer can be used, which enables all functions to be accessed after only a few clicks.
To organize the various actions possible, the functions are arranged in function groups. The Project Explorer orders the available actions according to their necessary sequence and thus conforms to imc's guiding design principle:

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...all the way from the sensor to the data sheet printout...

Below is a short introduction to the subgroups, which are explained in detail in later chapters.

2.1 Data capture

Data capture is performed by a hardware system comprising up to 16 input channels each operating at 50 kHz. The user interface provides control of the system.

2.2 Online data-processing

The result data are computed whenever possible during a running measurement.

2.3 Offline data-processing

For processing data coming from other sources, off-line analysis can be performed. The calculations done are based on the settings for the data acquisition. Thus, data already captured can be re-processed by changing the settings.

2.4 Curve display

There are screen windows for display of data. A screen can comprise up to four such curve windows. As a rule, all imc curve window settings can be made using the right mouse button. For ease of operation, the most important functions are also available via the menu and the toolbar in the main window.

2.5 Analysis

Data analysis is already under way during data capture. For printout, standard templates are available which can be easily filled and printed out by point-&-click. It is also possible to create layouts and to incorporate these into an existing project. In addition, a variety of graphic analysis techniques is available, from comparisons all the way to 3D waterfall and color map representation.

2.6 Import/Export interface

The import/export interface offers a variety of data types for importing and exporting measurement data.
The data to be saved are selected and written to the drive in the desired format.

2.7 Clipboard

The Clipboard makes it possible to keep data constantly at hand within a project, no matter what measurement is currently selected. This means

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that reference or tolerance curves can be added to and displayed in a curve window. The data can either be placed into the Clipboard directly from a measurement, or you can use imc FAMOS to generate a data set and load it to the Clipboard.

2.8 Sensor database

For quick parameterization of the inputs, a database for sensor data is provided. This database can be extended as desired by the user.

2.9 Calibrator database

The calibrator database is the logical extension of the sensor database. A calibrator for the calibrator database can be assigned to each sensor from the sensor database. This calibrator is used as the basis for adjusting the sensor. This makes it unnecessary to specify the calibrator's vibration values prior to the adjustment process.

2.10 Measurement objects

Measurements are performed on measurement objects. The measurement objects can be entered in a database and assigned to the appropriate measurements for better clarity. This makes it possible to compare only the measurements of a particular measurement object or to view the particular measurement object for a pool of measurements. The measurement objects are organized hierarchically and consist of measurement object types and measurement object components.

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3 Installing imc WAVE

This chapter provides instructions for installing imc WAVE, as well as tips concerning and answers to common questions related to the installation of imc WAVE.

3.1 imc WAVE installation instructions

Before installing imc WAVE, all other applications, especially imc programs, should be closed.

If you already have a version of imcDevices or imc WAVE on your PC, first uninstall these programs.

Place the installation-CD in the drive and start the program "*SETUP.EXE*".

Select the language in which to carry out the setup program.

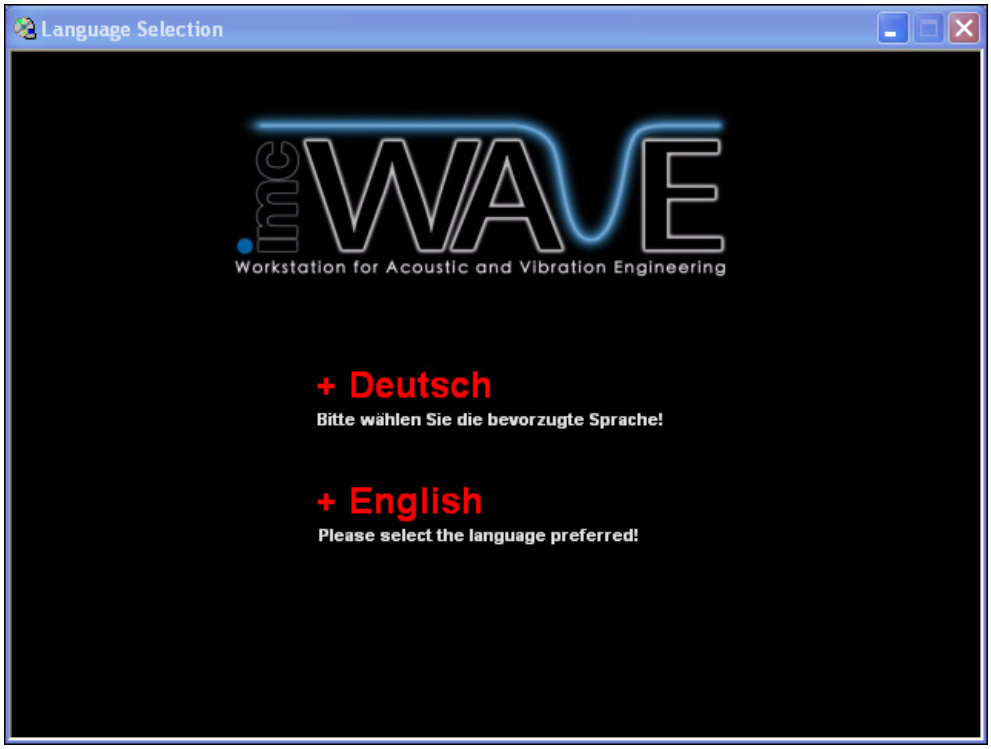

Fig. 2: Selecting the installation program language

Next, you can decide whether you wish to install imc WAVE, whether to read the documentation on the CD, and whether to install an Acrobat Reader for the purpose of reading the documentation.

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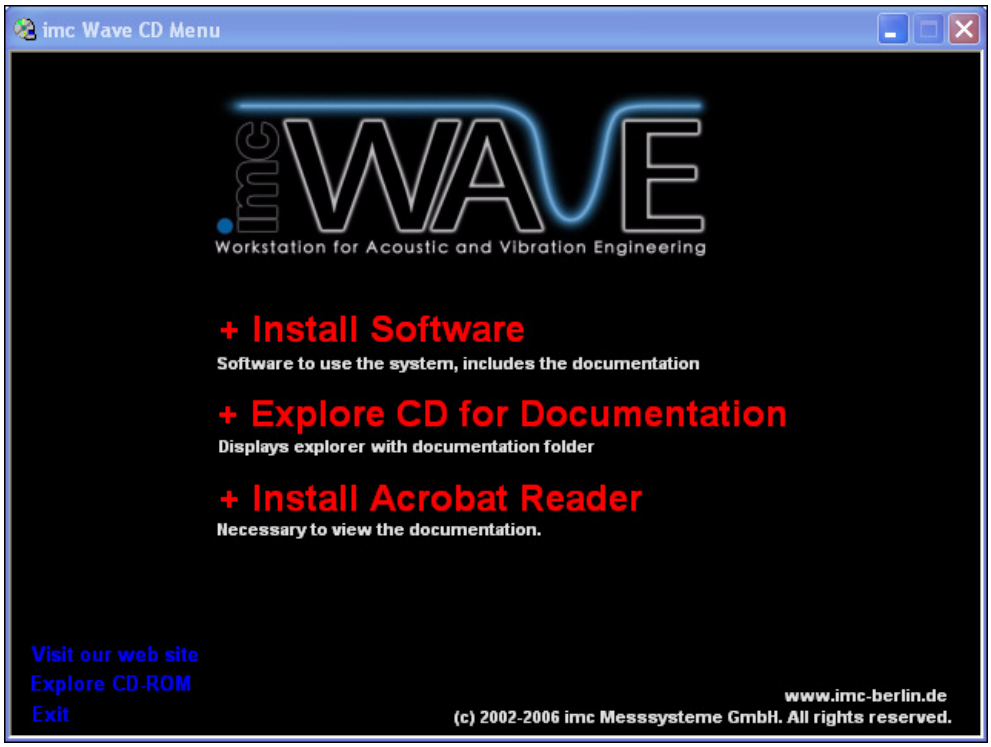
imc Wave CD Menu
imc WAVE
Workstation for Acoustic and Vibration Engineering
+ Install Software
Software to use the system, includes the documentation
+ Explore CD for Documentation
Displays explorer with documentation folder
+ Install Acrobat Reader
Necessary to view the documentation.
Visit our web site
Explore CD-ROM
Exit
www.imc-berlin.de
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Fig. 3: Selection dialog for the installation

Here, select “Install Software”.
In the subsequent dialog you are prompted for the installed software’s language. Select the language which you prefer for imc WAVE as well as imcDevices.

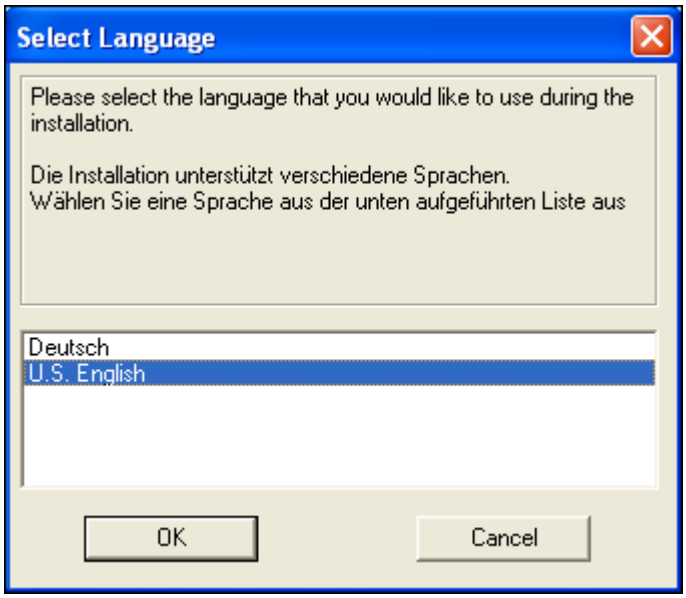
Select Language
Please select the language that you would like to use during the installation.
Die Installation unterstützt verschiedene Sprachen.
Wählen Sie eine Sprache aus der unten aufgeführten Liste aus
Deutsch
U.S. English
OK
Cancel

Fig. 4: Selection of the language version for the installed software imc WAVE

Once you have selected the language and have clicked on the OK button, the actual installation program for imc WAVE is started.

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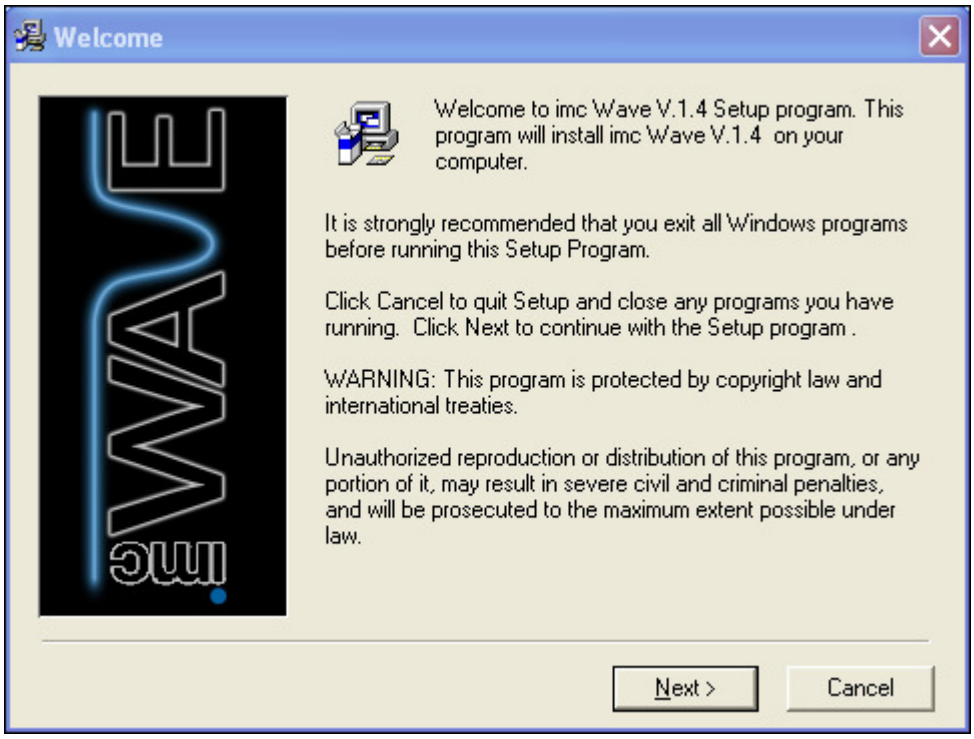
Welcome
Welcome to imc Wave V.1.4 Setup program. This program will install imc Wave V.1.4 on your computer.
It is strongly recommended that you exit all Windows programs before running this Setup Program.
Click Cancel to quit Setup and close any programs you have running. Click Next to continue with the Setup program .
WARNING: This program is protected by copyright law and international treaties.
Unauthorized reproduction or distribution of this program, or any portion of it, may result in severe civil and criminal penalties, and will be prosecuted to the maximum extent possible under law.
Next >
Cancel

Fig. 5: Welcome dialog of the imc WAVE installation program

If you now click on “Next”, the system checks whether any version of imc WAVE or imcDevices is already installed on your PC. A message such as the one shown below may appear:

VersionsInfo
Auf diesem Rechner wurden folgende Versionen gefunden: imc Devices V2.5
Sowohl imc Wave als auch imc Devices müssen vor der erneuten Installation deinstalliert werden.
OK
Abbrechen

Fig. 6: Notification of an installed version of imcDevices

If such a notification appears, stop the installation program and uninstall the version of imcDevices. The uninstalling procedure can be carried out by selecting the Control Panel item “Add/Remove Programs”. From the list of programs which then appears, select the entry for imcDevices or imc WAVE and click on the Change or the Remove button.

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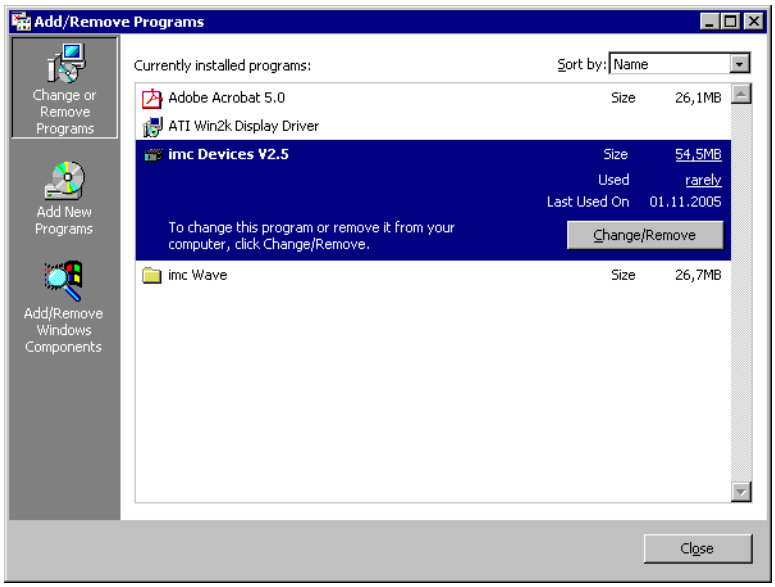

Fig. 7: Uninstalling imcDevices

If no notification appears, the installation program starts automatically and installs imc WAVE and the associated version of imcDevices on your PC.

In the next dialog, you can select the installation folder for imc WAVE.

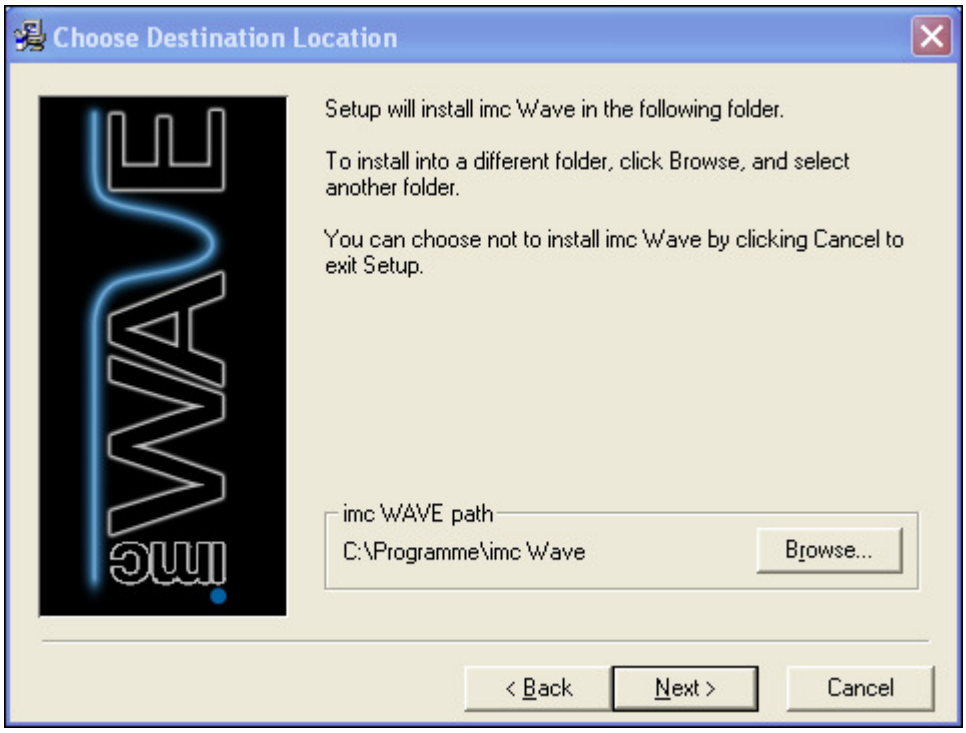
Choose Destination Location
Setup will install imc Wave in the following folder.
To install into a different folder, click Browse, and select another folder.
You can choose not to install imc Wave by clicking Cancel to exit Setup.
imc WAVE path
C:\Programme\imc Wave
Browse...
< Back
Next >
Cancel

Fig. 8: Selecting the installation folder for imc WAVE

You will be prompted to choose the group in the Start menu in which to create a shortcut to imc WAVE. It is also possible to create a new group for the purpose.

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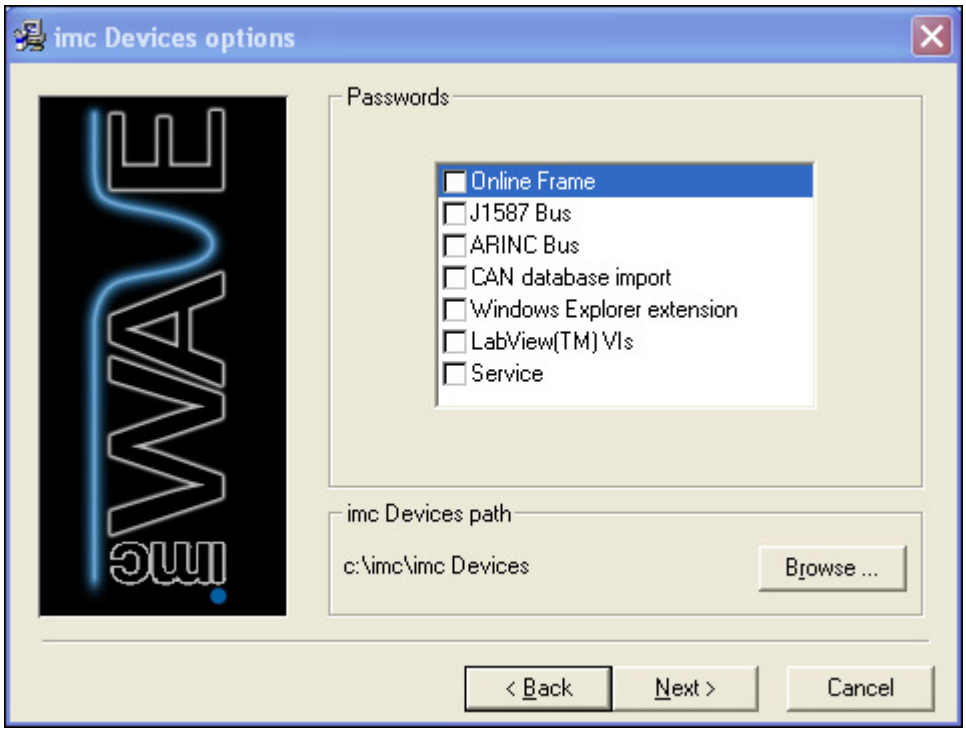

Fig. 9: Selecting the optional parameters and the directory of imcDevices

You can choose the optional parameters and the installation directory of imcDevices in the following dialog. The assistant for the CAN Bus interface will be installed automatically. Further options can be installed by selecting the corresponding lines in the list. For some of the options password are necessary. You got the passwords with the delivery of your system, if you have ordered the option.

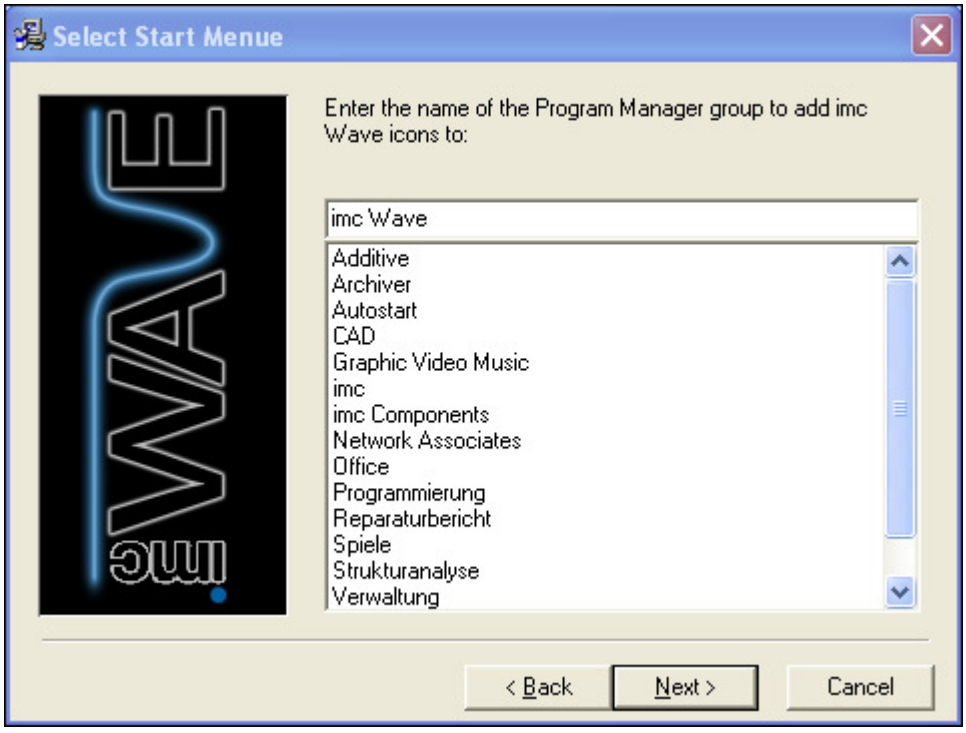

Fig. 10: Selecting a group in the Start menu

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With this, the preparations for the installation are completed and the actual installation process can begin. You can move through the sequence of dialogs by using the buttons “Back” and “Next”.

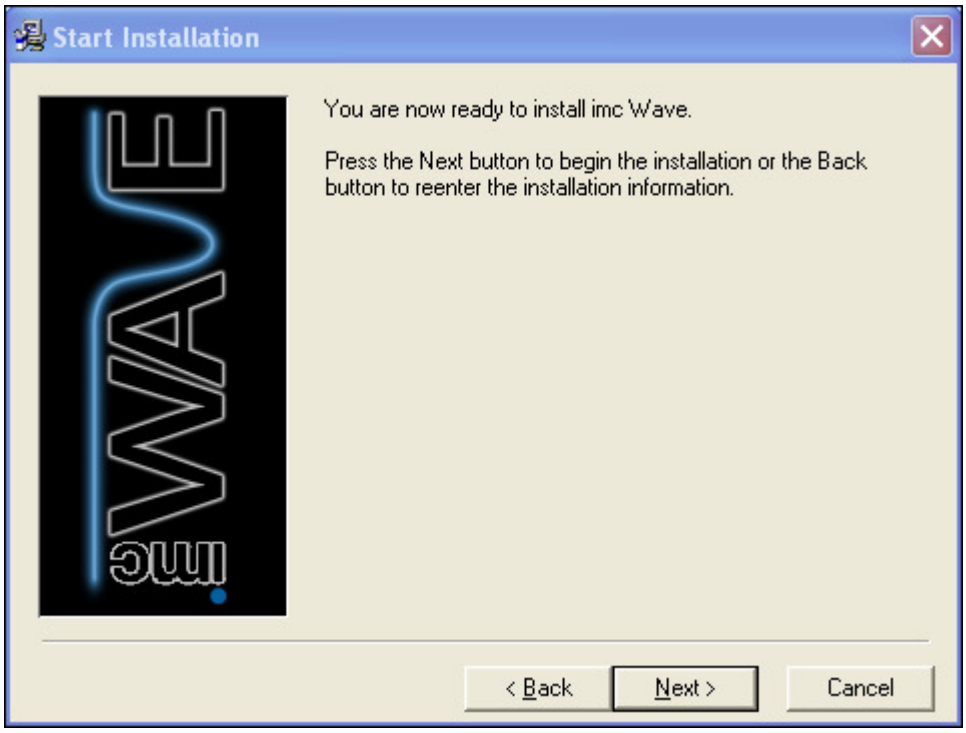
Start Installation
You are now ready to install imc Wave.
Press the Next button to begin the installation or the Back button to reenter the installation information.
< Back
Next >
Cancel

Fig. 11: Completing preparations for installation

Once the button “Next” in the last dialog has been clicked, installation of imc WAVE begins. Along with imc WAVE, a version of imcDevices is also installed, namely to the default folder C:\imc\imc devices.

Once all components were installed, the following dialog finally appears:

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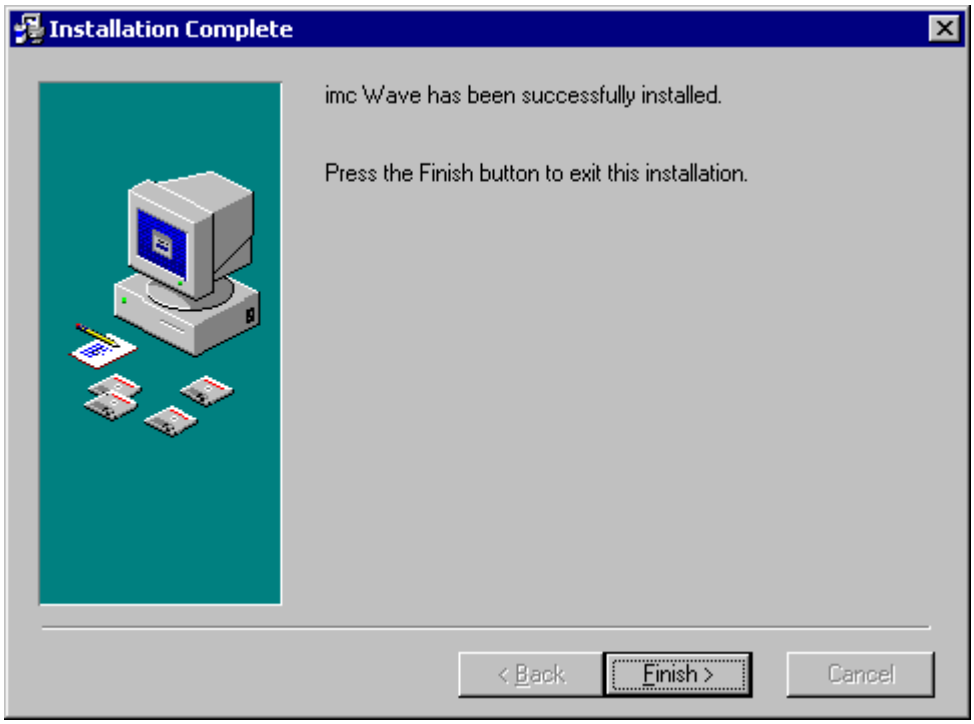
Installation Complete
imc Wave has been successfully installed.
Press the Finish button to exit this installation.
< Back
Finish >
Cancel

Fig. 12: Completing installation

Now imc WAVE and imcDevices are installed on your hard drive. To start one of the programs, click on the corresponding shortcut. If you are working with imc WAVE for the first time, observe the notes in the imc WAVE instructions manual as well as the notes in the manual for imcDevices or your measurement system.

If you have any questions or need tips, the authorized distributor for your area will be happy to help you.

If you discover any mistakes or have comments on this installation or on the manual, please contact us directly at WAVE@imc-berlin.de .

3.2 Frequently asked questions

3.2.1 Can I use a different version of imcDevices with imc WAVE?

As a matter of principle, your version of imc WAVE has been tested with one version of imcDevices. If you use a different version, then it could happen that incompatibility will cause imc WAVE to not work correctly. For instance, if an older version of imcDevices is used, imc WAVE could try to access imcDevices functions which weren't available until the present version. When in doubt, your local authorized distributor will be happy to assist you.

3.2.2 How can I install a new version of imcDevices?

imc WAVE accesses the imcDevices functions via the COM objects. Upon installation of imc WAVE, a RUNTIME version of these COM objects is

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installed on your PC. When imcDevices is uninstalled, these RUNTIME objects are uninstalled along with it, since they wouldn’t be compatible with any newly installed version. If you install a new version of imcDevices, it is necessary to install the imcDevices COM objects along with it. However, before you can install them, you will need a working installation of the basis COM objects from imc. These basis COM objects must be installed prior to installation of imcDevices. They aren’t included in either imcDevices or imc WAVE and must be purchased separately. To learn more, your local authorized distributor will be happy to assist you.

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4 The Project

imc WAVE is a project-oriented program package which administers and displays all data together with the project to which they belong.

4.1 Introduction

A project has the following components

- settings
- data
- displays
- and output options.

This somewhat abstract characterization may become clearer by taking a look at imc WAVE's Project Explorer.

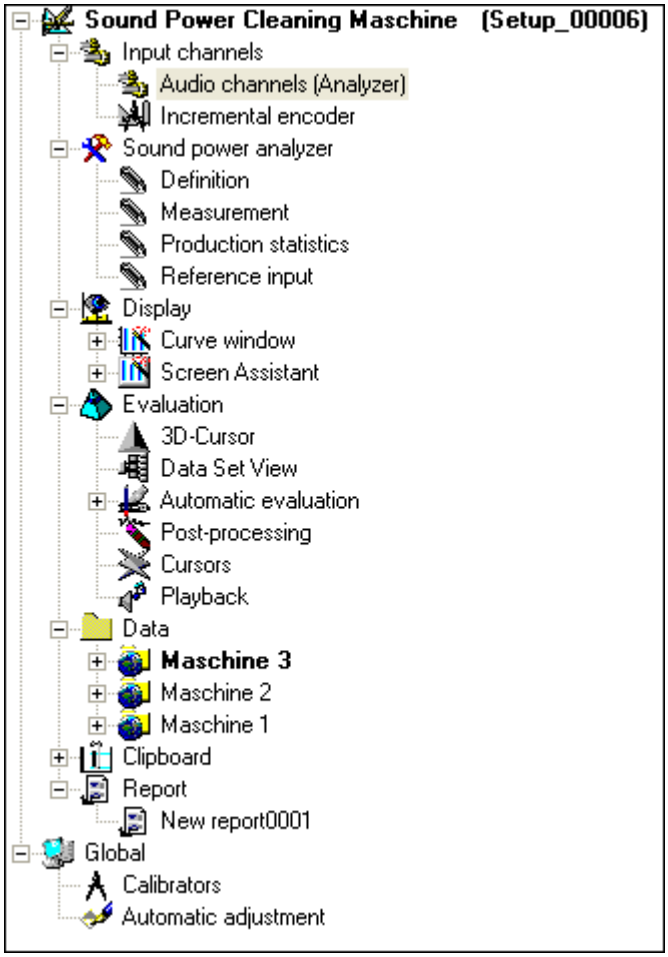

Fig. 13: imc WAVE Project Explorer

The Project Explorer is the easiest way to navigate through a project. In the Project Explorer you get a clear picture of a project's structure.

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A project consists of:

- the configuration of the input channels
- the configuration of the triggers
- the analyzer settings
- the displays
- the analysis options
- the data
- the Clipboard
- the reports.

The individual items are described below. Each of the items presented by the Project Explorer pertains to a particular project. When you switch to a different project, the data for the new project are opened and displayed in the Project Explorer.

It may become desirable to load settings from one project (e.g. the data display options) into another project. This can be accomplished using an import interface. See further below for details.

Alongside the settings particular to the projects there are also global settings which apply to all projects. These include, for example, the measurement objects and the sensor database. The data for these settings are administered globally and are available to all projects.

imc WAVE's project management system makes a compressed summary of all data and settings which are saved under a common project name.

4.2 How to create a project

The first step towards performing a measurement is to create a new project. You are prompted to do this when imc WAVE is started.

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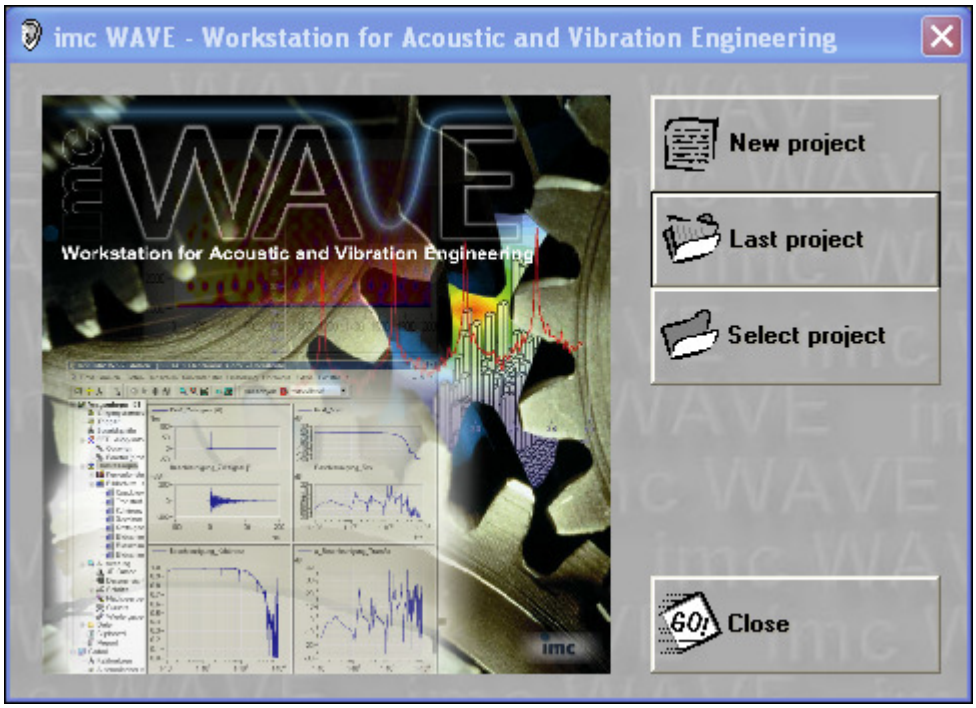

Fig. 14: imc WAVE Start dialog

The Start dialog offers you the choice of creating a new project, or opening the last project or any other already created project.

When you create a new project, the following dialog appears.

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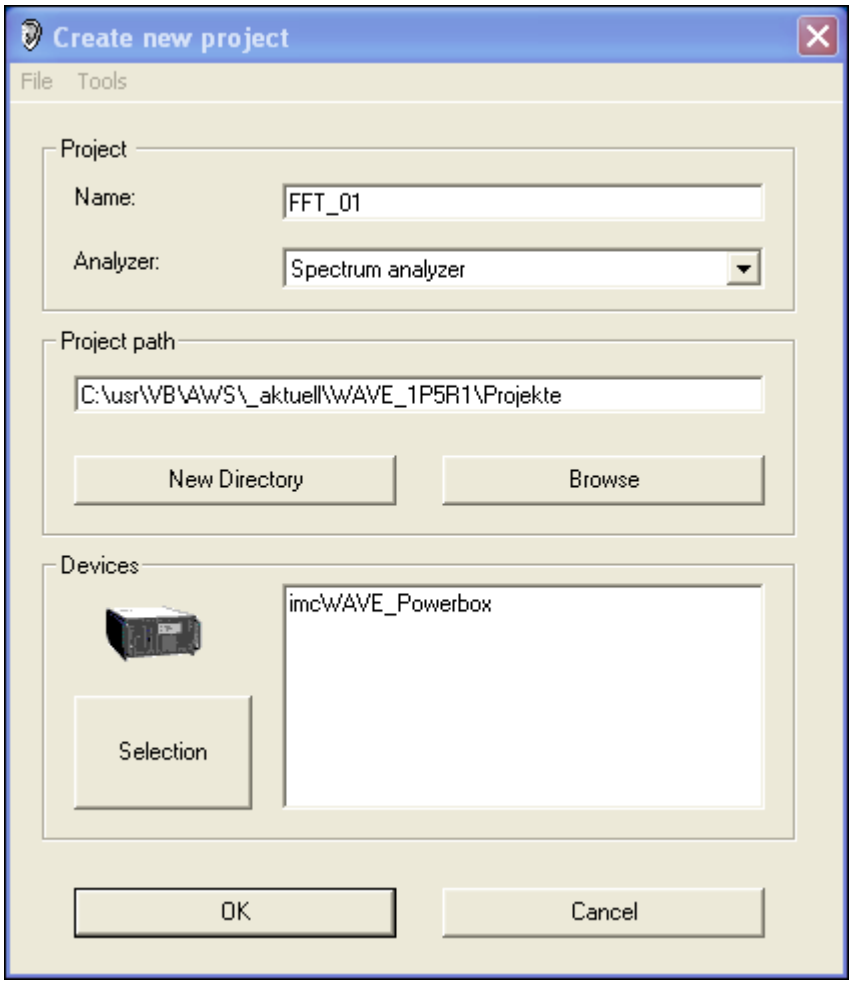

Fig. 15: Creating a new project

To create a project, the program requires

- a folder in which to save the project,
- a name under which to save the project,
- selection of the desired analyzer,
- and of the measurement devices with which to carry out the measurement

The analyzers from which to choose are presented in a list. The available selection of analyzers depends on which ones are enabled for your device (for detailed information, see the chapter: “How to enable analyzers”).

Once all information has been entered and confirmed by pressing the OK-button, the project is saved under the selected name in the selected folder.

You can now proceed to configure the project and perform measurements. Towards this end, once the definitions dialog is closed, the main imc WAVE window appears. In this main window, you can make all entries necessary for carrying out and administering the project.

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In the project's main menu, the "File" menu contains items for administering the projects. These include:

- **New project ...**
  Creates a new project with the help of the dialog described above.

- **Open project ...**
  Loads an exiting project.

- **Save project as ...**
  Saves the entire active project under a different name.

- **Delete project ...**
  Totally deletes the project from the hard drive.

- **Close project ...**
  The project is closed but not deleted.

- **Project properties ...**
  Displays the project's properties.

- **Save project as template ...**
  Saves the project as a template and can be selected when creating a project.

4.3 How to open a project

If you select the menu item "File – Open project ", the following dialog appears on the screen.

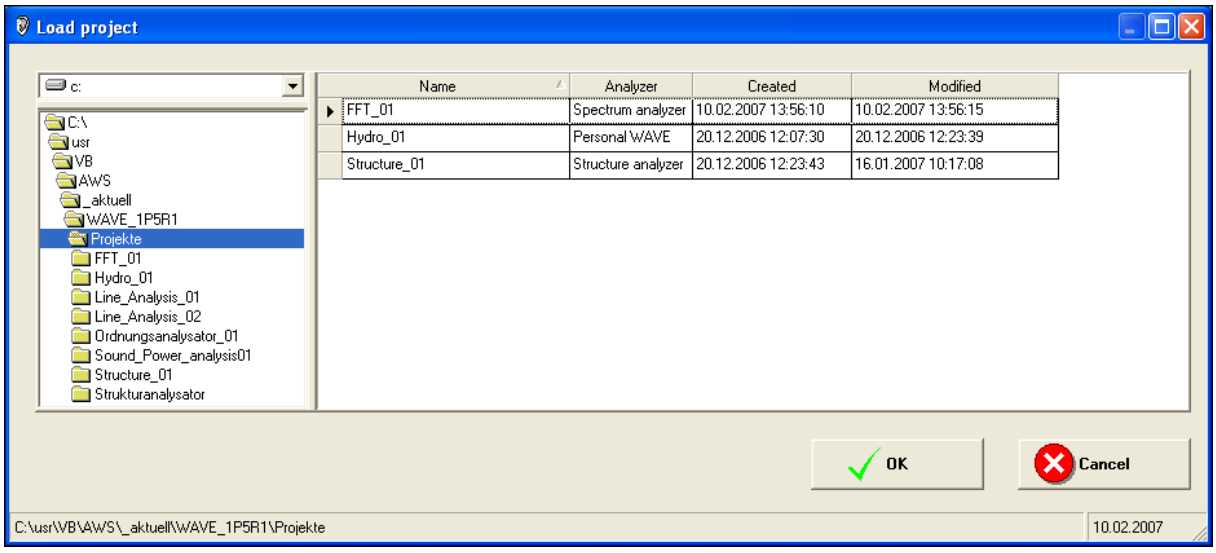

Fig. 16: Opening a project

This dialog can be used to load a previously created project. The dialog's left side shows a file explorer which you can use to browse through your

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computer's filing structure for folders containing projects to select. If you are already in a folder containing projects, these are automatically indicated in the table on the dialog's right-hand side. In this table, each project has its own line. These lines contain additional information, which includes:

- **Name**
  The project's name
- **Analyzer**
  Analyzer with which the project was created
- **Created**
  The project's creation date
- **Modified**
  The date when the project was last modified

These data enable a project to be identified exactly. To load one, click on the desired line in the table to select it, which is indicated by an arrow beside it. When you then close the dialog using the "OK" button, the currently selected project is loaded. If you click on "Cancel", you exit the dialog without loading any new project.

4.4 How to enter the project properties

imc WAVE enables you to save information on your project. To do this, double-click on the project's name in the project explorer's top row.

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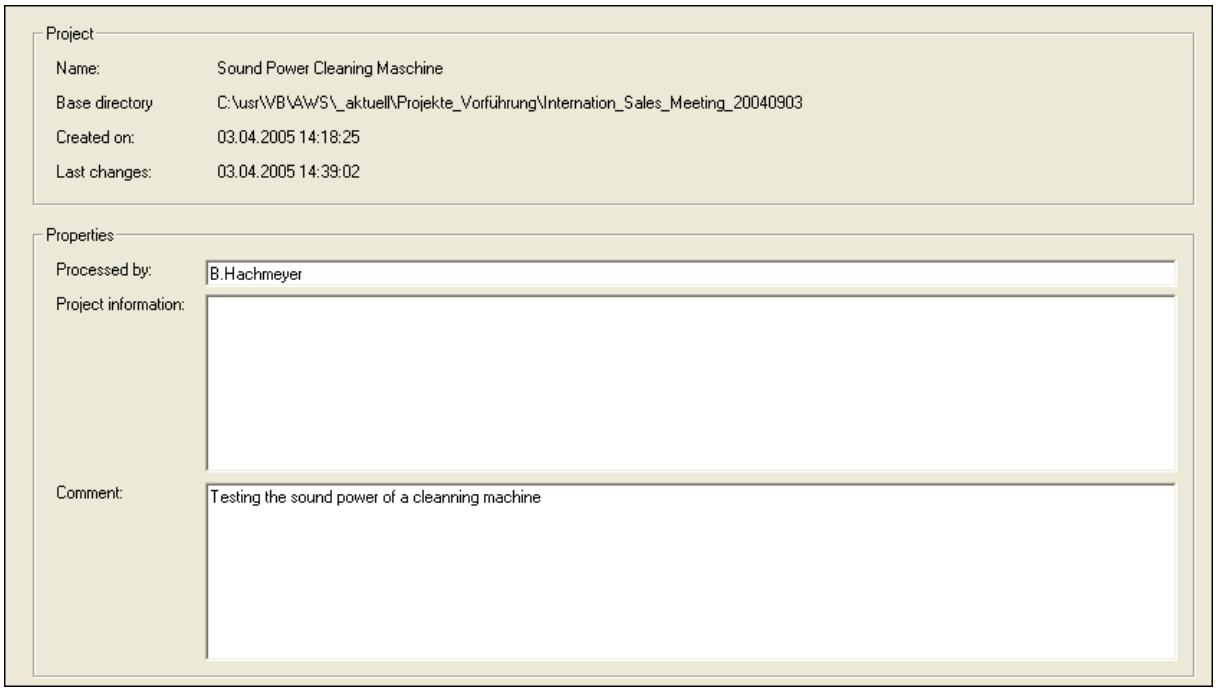

Fig. 17: Dialog for entering the project properties

The dialog for describing the project presents the information provided by imc WAVE, such as

- the project's name,
- the project's base directory,
- the project's date created, and
- the date most recently modified,

as well as the ability to add more data. For this purpose, the boxes

- Processed by
- Project information, and
- Comment

are provided.

These data are stored globally in the project and are overwritten upon every change.

4.5 What is a project template?

imc WAVE assigns one analyzer to each project. The user supplies these analyzers with specific supplemental data such as display and analysis choices in order to meet the given requirements. Thus, the project represents a complete description of your measurement task. Naturally, it's a pretty big job to collate all the data for a project, especially when dealing with repeated measurement runs which are to be administered in a number of different projects. Thus, imc WAVE comes with the option to save project templates. Such a template would then be an available

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choice when creating a project, in which the specific project data you have defined are already provided.

You define your project and can already run some measurements in order to check that all settings have been made correctly. Then you can select the project by way of the menu item "File – Save project as template". You are then prompted to enter the template's name.

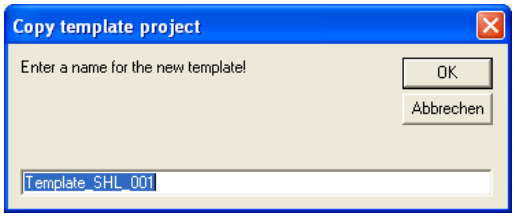

Fig. 18: Name of the project template

Enter a name and confirm it by clicking on the OK button. Then the project has been saved as a template.

The next time you create a new project and open the dialog for configuring the new project, this project template appears in the list of analyzers.

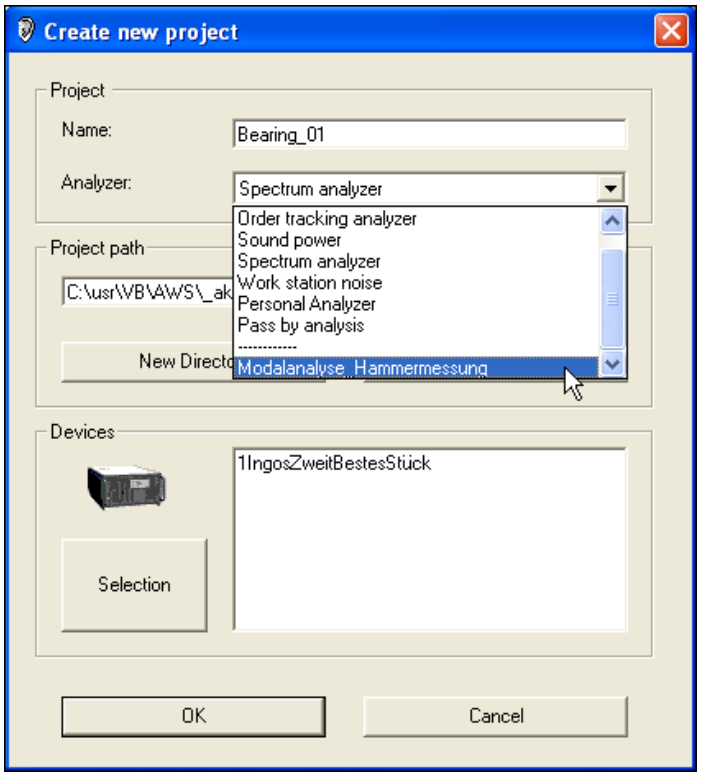

Fig. 19: Creating a new project with the help of a project template

Thus, you can consider the project template to be a new analyzer. You thus have the ability to create template analyzers from your own projects, which contain all necessary settings and which can be run at the push of the Start-button.

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5 Input Channels

5.1 Introduction

imc WAVE distinguishes between the input and output channels of the analyzer selected.

The physical inputs of the measurement system you use are referred to as the analyzer's input channels. The number of input channels and their properties depend on your particular device.

The analyzer selected processes the measurement device's physical input channels to determine the output channels' signals.

Example
If you select a Structure Analyzer and have it compute the input channels' auto power density spectrum, the auto power density spectrum amounts to the analyzer's output signal.

The formal separation between input and output channels is reflected in the Project Explorer. Configuration of the input channels takes place under the heading **"Input channels"**, configuration of the output channels under the analyzer involved.

Settings for the input and output channels are particular properties of a project. If the configuration is changed between individual measurement runs, a new **setup** is thus automatically created, in which further operation proceeds. Measurements carried out by the present time are still associated with the old setup, so that the configuration is not lost but can be restored. For detailed information on creating and administering setups, consult the chapter of this manual which is devoted to them.

5.2 How to make input channel settings

Clicking on the entry "Input channels" in the Project Explorer opens the dialog for configuring the input channels.

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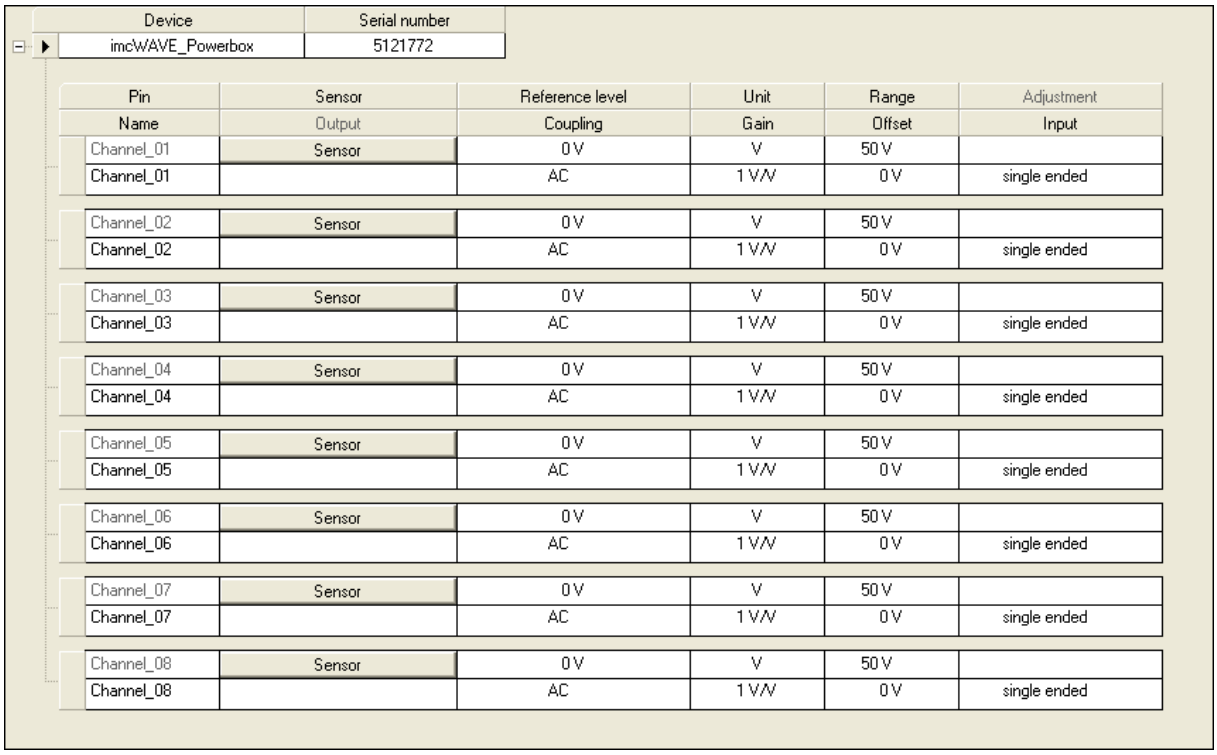

Device	Serial number
imcWAVE_Powerbox	5121772

Pin	Sensor	Reference level	Unit	Range	Adjustment
Name	Output	Coupling	Gain	Offset	Input
Channel_01	Sensor	0 V	V	50 V	
Channel_01		AC	1 V/V	0 V	single ended
Channel_02	Sensor	0 V	V	50 V	
Channel_02		AC	1 V/V	0 V	single ended
Channel_03	Sensor	0 V	V	50 V	
Channel_03		AC	1 V/V	0 V	single ended
Channel_04	Sensor	0 V	V	50 V	
Channel_04		AC	1 V/V	0 V	single ended
Channel_05	Sensor	0 V	V	50 V	
Channel_05		AC	1 V/V	0 V	single ended
Channel_06	Sensor	0 V	V	50 V	
Channel_06		AC	1 V/V	0 V	single ended
Channel_07	Sensor	0 V	V	50 V	
Channel_07		AC	1 V/V	0 V	single ended
Channel_08	Sensor	0 V	V	50 V	
Channel_08		AC	1 V/V	0 V	single ended

Fig. 20: Configuring input channels

Each channel can be configured separately.

The following settings options are available:

- **Pin**
  Permanent identifier for the input channel
- **Name**
  Freely specified by the user, however, be sure that the name does not include any special characters if the data are to be subjected to further processing by other programs (e.g. imc FAMOS).
- **Sensor**
  When this button is pressed, the sensor database's selection dialog appears. You then have the ability to link your input channel permanently to a sensor's output, and thus to load its settings directly from the sensor database. Since some sensors have multiple outputs, (e.g. triaxial sensors or impedance probes) the output you select in the box "output" is displayed in the configuration line.
- **Output**
  The name of the selected sensor's output, taken from a sensor database, is displayed in this box. If the input channel isn't linked to a sensor database, the box remains empty. Linking the database can be carried out by pushing the button "Sensor".
- **Reference level**
  Definition of the reference level for converting the physical measurement quantity to a level; if a reference level is specified,

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conversion is performed on-line during the measurement. If zero is specified as the reference level, the measurement quantity is returned with a linear y-axis.

- **Coupling**
  Type of coupling to the measurement device (e.g. AC or DC). The available choices depend on the measurement device used.
- **Unit**
  The input channel's physical unit.
- **Gain**
  Scaling factor for converting the raw data to the desired physical quantity; the specification is in the physical measurement quantity/ Volt (e.g. 25.4 Pa / V).
- **Range**
  End value of the range; the available choices depend on the measurement device used.
- **Offset**
  Here you can set an offset to add to the physical measurement quantity. Specified in the input signal's physical unit.
- **Adjustment**
  Information about the last adjustment process of these channel
- **Input**
  Please choose here the kind of input circuit your sensor needs

Once all these parameters have been entered, configuration of the input channel is complete.

You also have the possibility to switch from a two-column display to a single-column display. To do this, right-click in the dialog and remove the checkmark in front of the menu entry "Two-line display". The configuration data are then displayed in a line for each channel.

If you have linked the channel with a sensor from the sensor database, you can switch off all settings, which are determined by the sensor database. To do this, right-click in the dialog and remove the checkmark in front of the menu entry "Display configuration data". Then, only such configuration data will be displayed which are not determined by the sensor database.

The dialog also offers more functions which are accessed by right-clicking the mouse over the button in front of each input channel.

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This calls a menu offering the following options:

- **Sensor database**
  This menu item calls the selection dialog for the sensor database, from which you can select a sensor to link with the current channel.
- **Disconnect**
  If you have already linked a sensor from the sensor database to the current channel, this menu item lets you remove the link while retaining the other channel settings.
- **Sensor definition**
  If a sensor from the sensor database is already linked to the current channel, you can access the sensor settings directly from here.
- **Adjustment**
  This menu item calls the dialog for performing adjustments for the current channel. How to carry out adjustments is described in another chapter.
- **Two line Display**
  Toggle between display of the configuration data in one or two lines.

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6 Setups

6.1 Introduction

A setup in imc WAVE refers to the configuration of all components, including the configuration of the input channels, the output channels, the trigger settings etc.

An example can serve to illustrate the administration of setups:

> We create a new project, configure it according to our requirements and carry out approx. 100 measurements. Now, after about 100 measurements, we notice that the wrong windowing function has been set for the FFT. But we don't wish to discard the 100 measurements, since in spite of the incorrect setting we have gained some useful information worth analyzing. We reset the windowing function and start over until we obtain the desired amount of measurements, say 200. Now we have 100 measurements performed using window function X and another 100 using window function Y. After 12 weeks we decide to analyze the data but no longer remember which data were performed using which function.

This hypothetical situation will not necessarily reflect your actual experimental practice, of course.
There are two approaches to solving the problem outlined above:

1. Make an extensive and accurate lab report at the right time.
2. Perform the whole experiment using imc WAVE.

Solution 1 is up to the user.

In Solution 2, imc WAVE handles the administration of the entire configuration for you, in the background.

imc WAVE notices if the configuration changes during a running measurement and automatically associates the data with a new setup. This means you don't need to take care of the administration and experiment logging yourself, but can instead concentrate on dealing with the substance of your task.

When you view data, the correct configuration is automatically indicated, or you can intentionally load a certain setup and conduct the next measurement using it.

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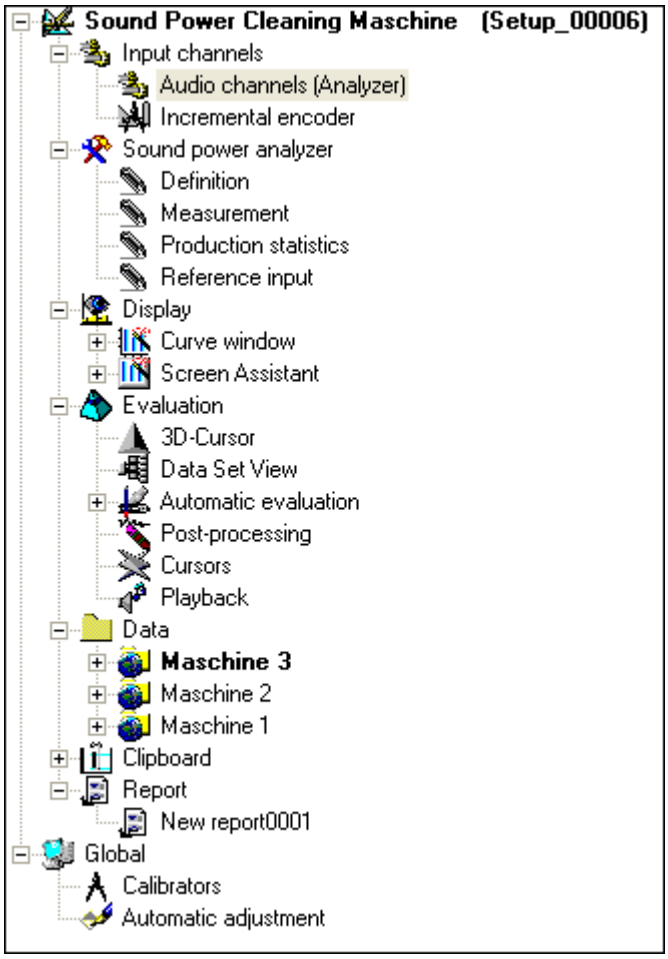

Fig. 21: Display of the current setup

The setup currently selected is displayed in the Project Explorer after the project name. The default names assigned by imc WAVE for setups are simply serial numbering.

Administration of the setup is performed via the menu item "Setups". Here you can activate individual setups manually and edit their names.

Under the menu item "Setups – Options", you can determine whether or not the setups for the current measured data are loaded.

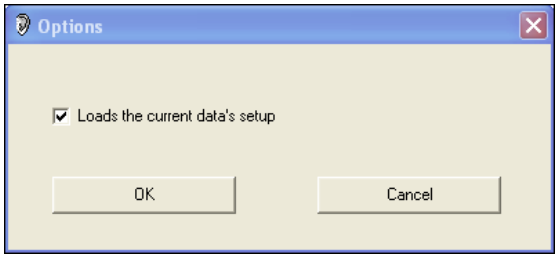

Fig. 22: Setup options

Another example will explain this:

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We have made the 200 measurements described above and now page through the measurements to view them (see also the chapter on displaying measurements). For instance, we view Measurement 98, which was conducted with the 1st setup and next Measurement 102, conducted with the 2nd setup.

If the option "Load setting of current measurement data" is activated, the matching setup for the data is automatically loaded. If the option is not activated, the last setup used for a measurement is loaded.

Note that if this option is activated and you last view Measurement 98 before proceeding with a new measurement, the new measurement is carried out using Setup 1, even though the most recently performed measurement used Setup 2. Therefore, if this option is active, always make sure of which setup was used with the current measurement.

However, it is always possible to manually activate the desired setup and the configuration of your measurement system is totally adaptable.

6.2 How to change setups

imc WAVE offers the following possibilities for accessing different setups:

- Activate
- Rename …
- Import

These choices are available in the "Setups" menu in the imc WAVE main window.

Activating a setup
You can activate any setup of your choice, for instance, in order to carry out measurements according to that setup. To do this, select the menu item "Setup – Activate…".

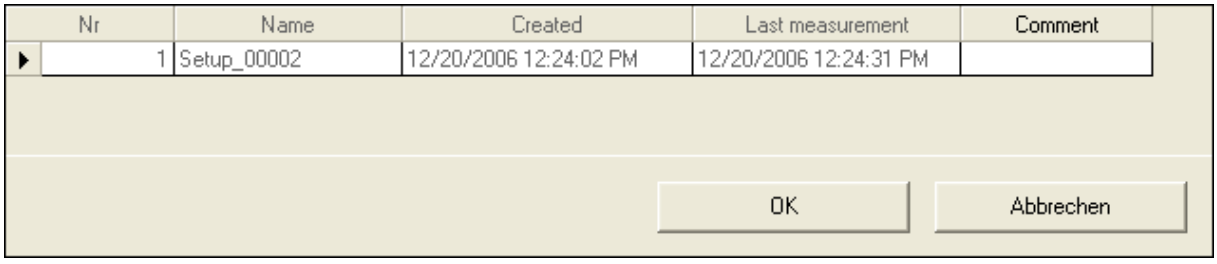

Fig. 23: Selection dialog of setups to activate

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In the subsequent dialog, all of the project's setups are listed, each with an entry for its name, date created, date last used, and any comment which may have been recorded. The arrow in the table's first column indicates which setup is currently selected. Simply by re-positioning this arrow, you can select a different setup.

Changing a setup's name

Setups are assigned a default name, so that it's not necessary for you to supply one when creating a new setup. But if you wish to change a setup's name, select the menu item "Setup – Rename". In the dialog which then appears, the setup's name can be edited.

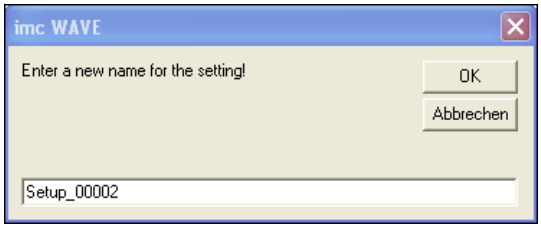

Fig. 24: Editing a setup's name

Importing a setup

You also have the option to import setups from other projects. To do this, select the menu item "Setup – Import". The dialog which then appears presents all setups belonging to known projects of the same type as the project on which you're currently working.

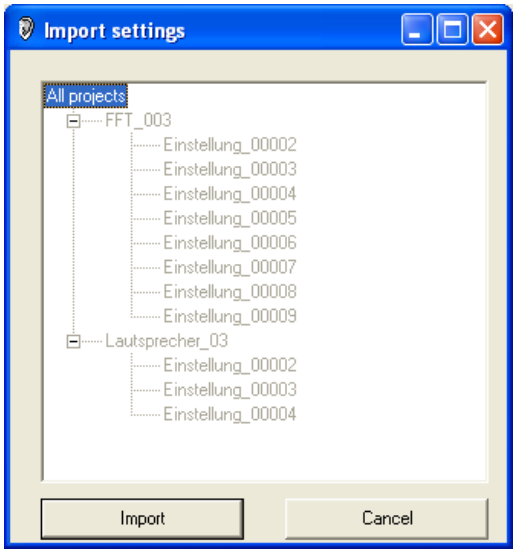

Fig. 25: Importing setups from other projects

The list may also display some projects shaded gray, which means they are disabled. Such projects are structured differently (e.g. the number of devices involved is different), so that the setup concerned couldn't be imported into your project.

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To import a setup, select the one desired and confirm your choice by clicking on the button "Import".

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7 Triggers

7.1 Introduction

imc WAVE supports one trigger. For each channel, an event, called a trigger event, can be defined, whose occurrence causes an action to take place. The events can be composed of conditions linked by the logic operators "AND" or "OR".

You thus have the option to use the signal of any of your analyzer's input channels as the triggering event for the measurement, or to link events.

The trigger's configuration is one of a project's properties. Triggered measurement is no longer supported for measurements carried out with multiple devices. If the devices were synchronized before the start of the measurement, however, the order of the data is correct.

7.2 How to make trigger settings

The trigger's configuration is displayed when you click on the entry **"Trigger"** in the Project Explorer.

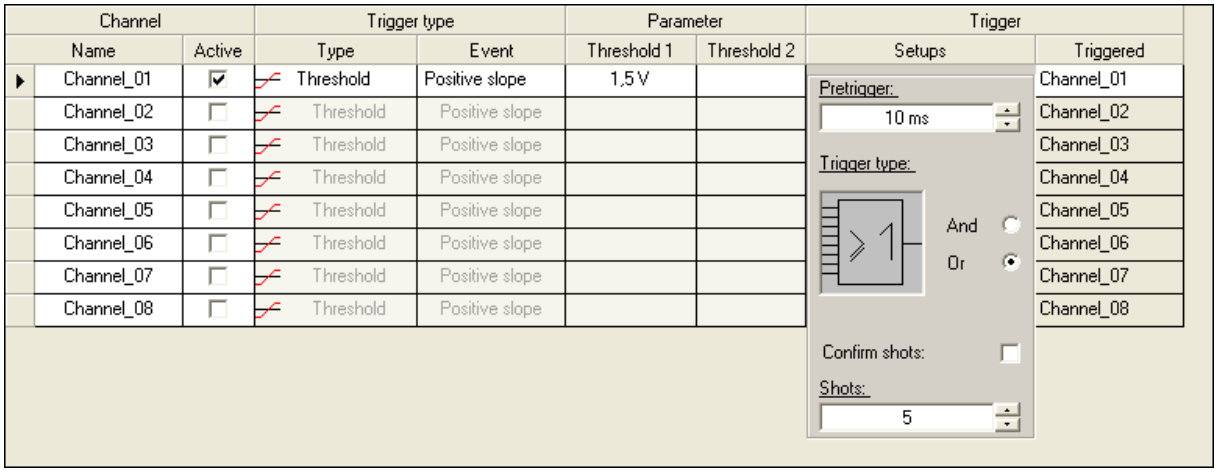

Fig. 26: Configuration dialog for the trigger

To define a trigger, activate the desired input channel in the trigger dialog.

Next, you select the event type. The various options available for this are selected by making the appropriate settings for the following parameters:

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Threshold value
Definition of a threshold value "Threshold 1" with the following events

- **Positive slope**
  trigger event is rising slope passing through the threshold,
- **Negative slope**
  trigger event is falling slope passing through the threshold,
- **Greater than threshold**
  trigger event is measured values higher than threshold,
- **Less than threshold**
  trigger event is measured values lower than threshold.

Range
Definition of a signal range with the limits "Threshold 1" and "Threshold 2"

- **Entering range**
  trigger event is measured values entering range,
- **Exiting range**
  trigger event is measured values exiting range,
- **Within range**
  trigger event is measured values falling within range,
- **Outside range**
  trigger event is measured values falling outside of range,

After the events are defined, a pretrigger and event linking can also be set up.

The various analyzers each have their own particular settings (e.g. manual takeover for the Structure Analyzer); these settings will be discussed in connection with their respective analyzers.

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8 Analyzers (introduction)

Formally, an analyzer transforms the input signals into output signals by means of an algorithm. The output signals are then available for display and evaluation.

An analyzer is selected when creating a project and is permanent for the duration of the project. It is a fixed property of a project; it cannot be changed within a project.

Depending on the analyzer selected, different settings and processing steps are available.

The description of the analyzers will appear further below.

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9 Graphic Display

Display of measurement results in imc WAVE is based on the imc curve window. We distinguish between a "screen" and a "curve window", where a screen can comprise multiple curve windows.

9.1 The Screen

A screen is a collection of curve windows within a window. There are any number of ways to make and save layouts of graphics displays.

A screen is a property of a particular project but can be imported from another project.

Already saved screens are to be found in the Project Explorer under the heading "Displays – Screen Assistant".

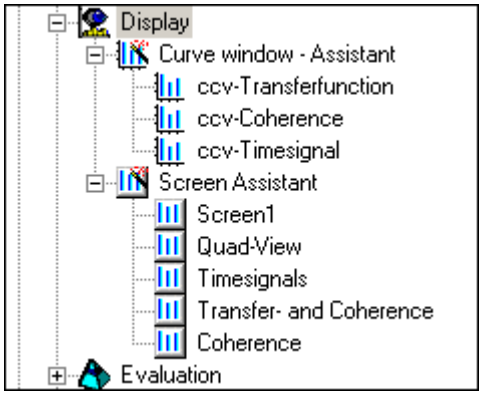

Fig. 27: Screens in the Project Explorer

9.2 How to create a screen

There are two ways to create a new screen.

1. Directly, using the main menu
   This interface provides a relatively quick and easy way to create or modify screens during "running" operation.

2. With the aid of the Screen Assistant
   The Screen Assistant is an easy-to-use graphical interface specially designed for setting up screens quickly and easily. To use it, however, it's necessary to call the Assistant separately.

Both options have their advantages and disadvantages. The two methods are described below.

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9.2.1 Creating and modifying screens directly

To create a new screen, start by clicking on the menu item "Screen – New" and in the dialog which then appears enter a name for the new screen. A new entry will then appear in the Project Explorer, having the name you previously entered. The screen name may have a maximum length of 29 characters. The new screen appears in imc WAVE's workspace.

Now you can choose how many curve windows to place in the screen. To do this, click on the menu item "Screen – Partition", where the following options are offered:

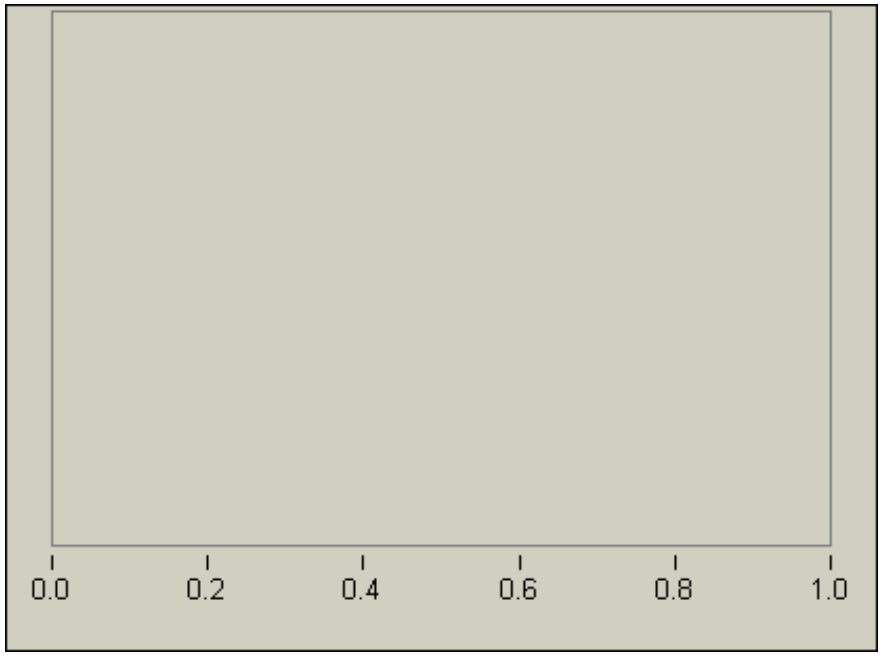

Fig. 28: Single screen

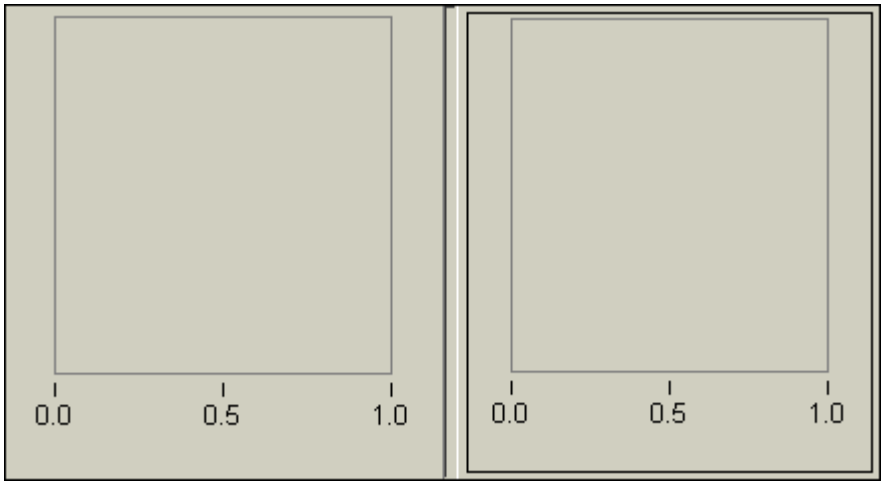

Fig. 29: Vertical two-tile screen

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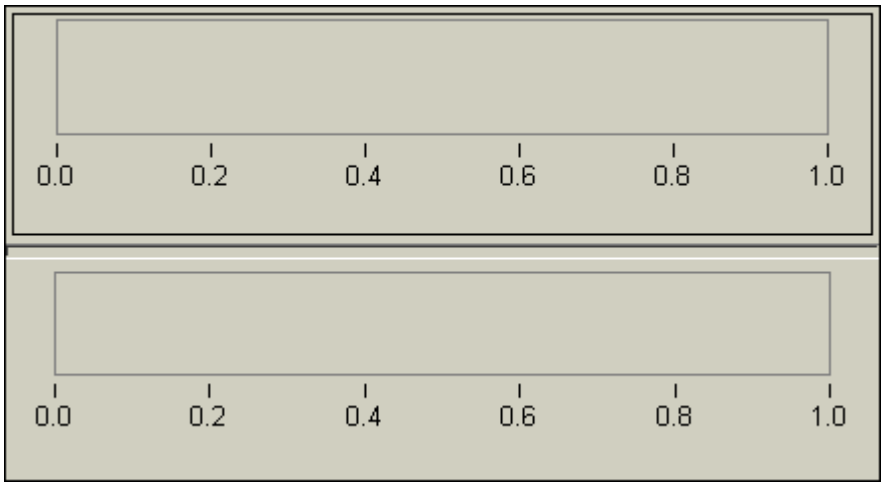

Fig. 30: Horizontal two-tile screen

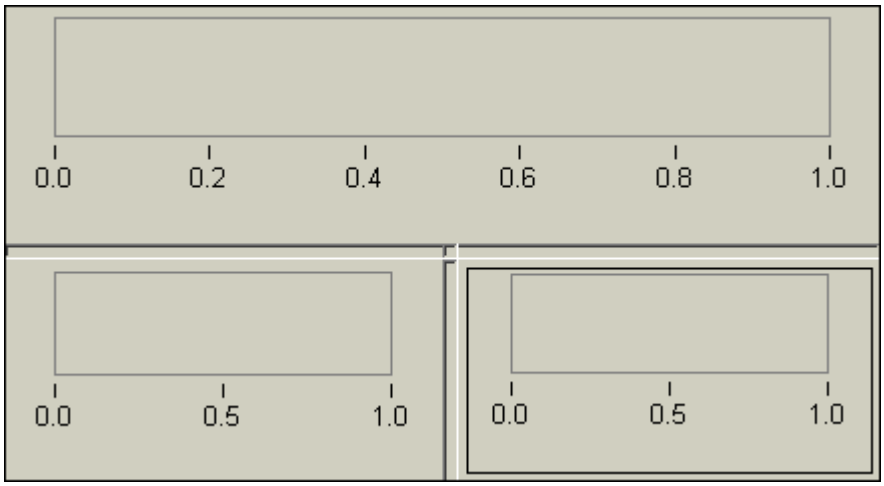

Fig. 31: Vertical three-tile screen

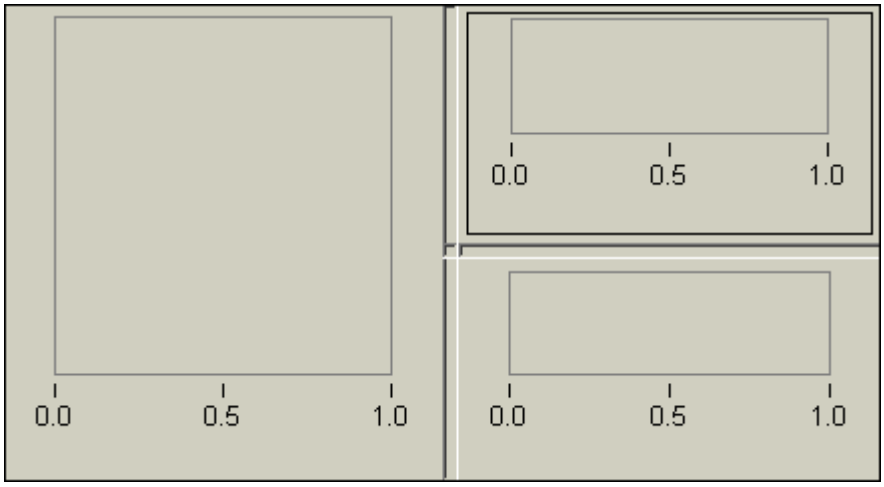

Fig. 32: Horizontal three-tile screen

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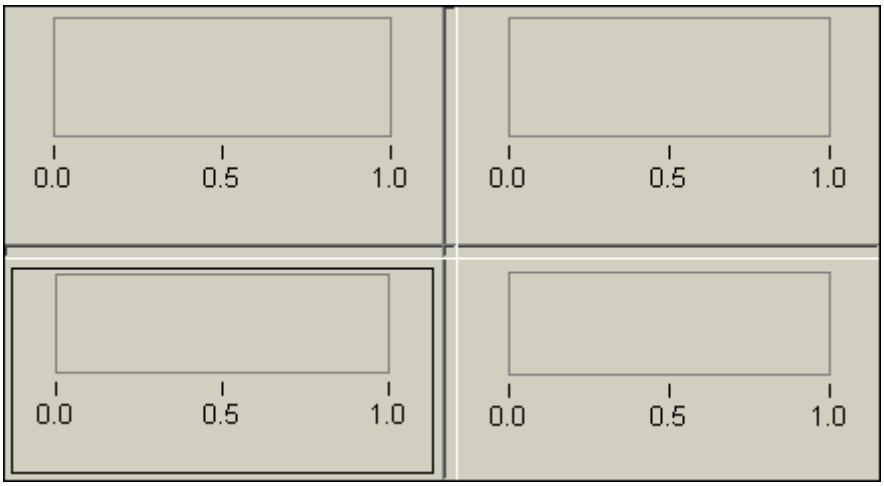

Fig. 33: Four-tile screen

Depending on the partitioning selected, one to four curve windows are displayed on your screen. The layout of the screens is constant, but the size of the screens can be changed. To do this, you can grab the bar between the curve windows by clicking and holding down the left mouse button over it, then shift it to the desired location and leave it there by releasing the mouse button.

Each of these curve windows can be configured individually. Configuration is described in the next section.

After adapting the screens (size, partitioning, assignment of curve configurations, etc.) the screen must be saved so that the changes will be restored upon the next call. For this purpose, the menu items "Save" and "Save as.." are available in the "Screen" menu.

Additionally, you can edit a screen's name or delete whole screens. For this, there are corresponding menu items.

9.2.2 Working with the Screen Assistant

The Screen Assistant is started by double-clicking on the Explorer entry "Screen Assistant" under "Display".

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Fig. 34: Screen Assistant

The Screen Assistant consists of a toolbar and its associated screen below. You can use the toolbar tools to either generate screens or to modify existing screens.

We now create a new screen by clicking on the icon

. We will then be prompted to supply a name for the new screen and enter a name in the dialog which then appears.

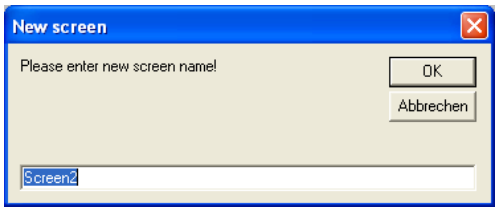

Fig. 35: Name for the new screen

After confirming, the screen looks like the illustration below.

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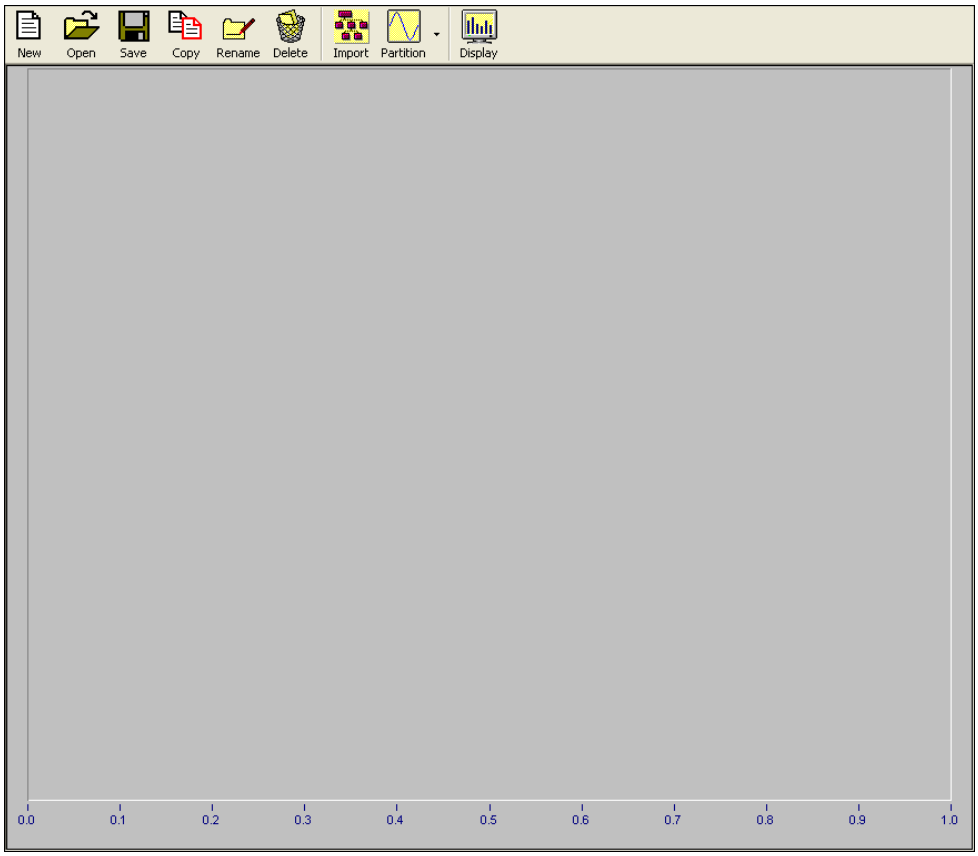

Fig. 36: New screen

Next, we select the desired tiling for the screen by using the button "Partition".

The partitioning styles available are the same as described in the section above:

1. Single screen
2. Two-tile horizontal
3. Two-tile vertical
4. Three-tile horizontal
5. Three-tile vertical
6. Four-tile

Four our example, we select "Four-tile" display. Now our screen looks like this:

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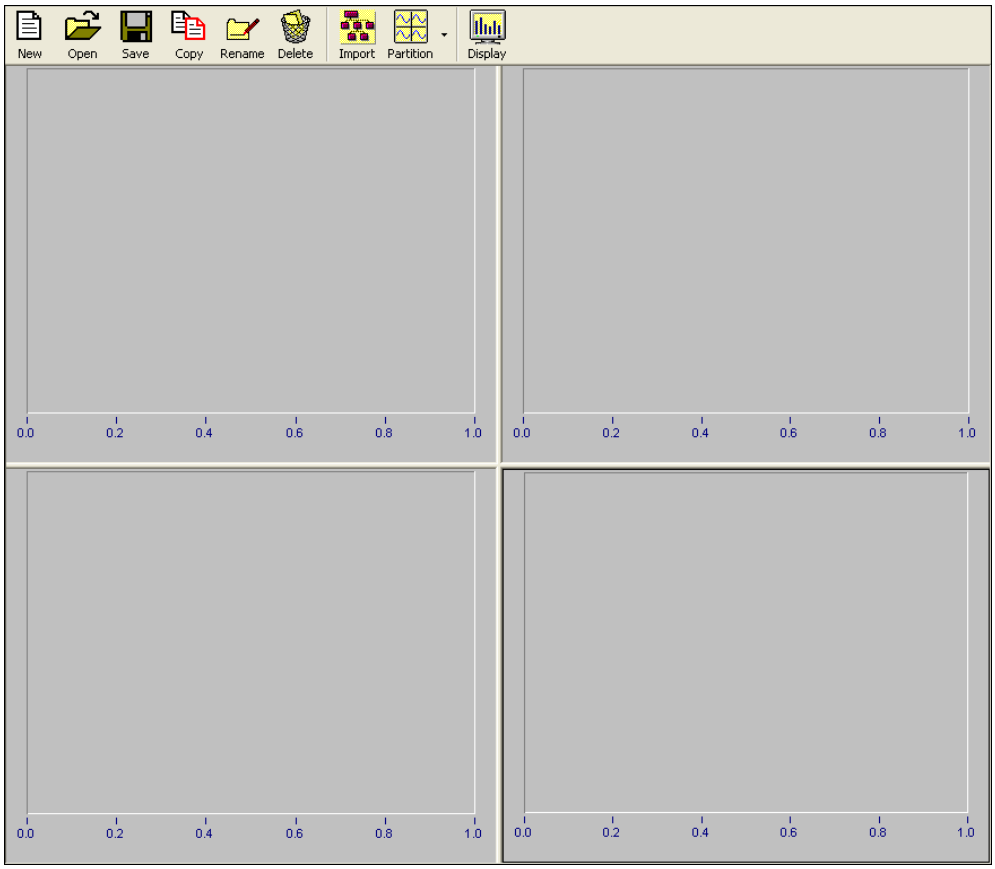

Fig. 37: New screen with 4-fold tiling

The separator lines between curve windows can be shifted at will by the user, making it possible to show windows of different sizes. To change the size of a curve window, grab its separator line with the mouse and simply drag it to a new position. For instance, you could obtain the following appearance of the curve windows:

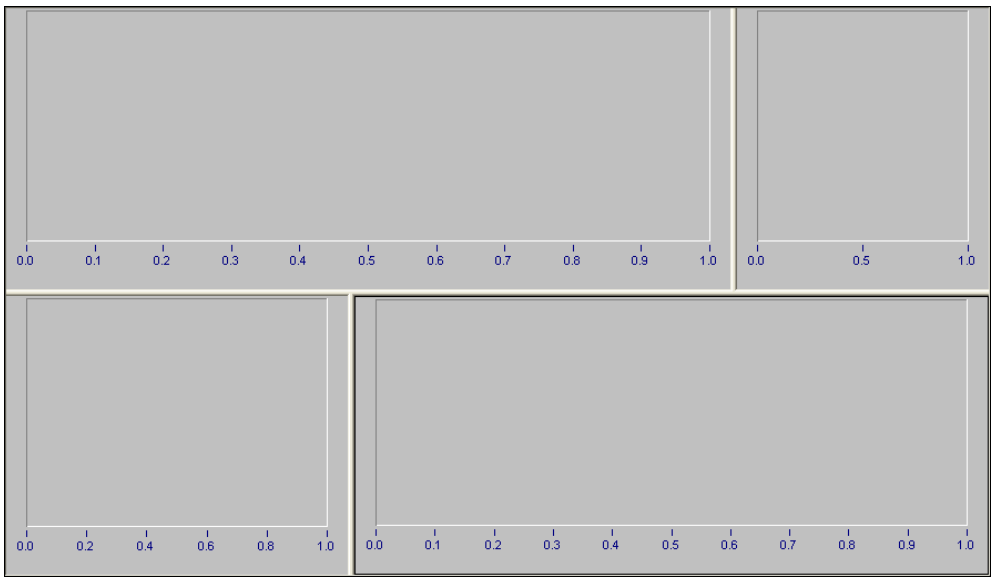

Fig. 38: New screen with modified curve window sizes

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Now we can fill the four empty curve windows belonging to the screen. To do this, we use the Drag&Drop technique to select a curve window from the Project Explorer under the heading "Curve Window Assistant" and drop it into the desired empty coordinate system window.
Once we've filled all four curve windows, we can save the screen using the button "Save".

To exit the Screen Assistant and have the screen you created displayed, click on the button "Display". The Assistant is then closed automatically and the last active screen is displayed.

In addition to these functions, the toolbar also offers additional functions.

Open
Opens the dialog for selecting a screen

Copy
Copies the currently open screen to another screen. This enables you to duplicate screens.

Rename
For renaming the currently opened screen

Delete
Lets the user delete the currently active screen. A message prompts you to confirm your decision before deletion takes place.

Import
Importing screens is described in a separate section of this chapter.

9.3 Curve windows

Particular configurations of the imc curve window, determining their appearance and contents, can be saved. There is a large number of options affecting all aspects of a curve window. To learn of the many functions and settings available, refer to the manual "imc Curve Manager".

A saved curve window is a means of avoiding the need to design and configure curves at each use.

A curve window is a particular property of a project, but like a screen, it can be imported from other projects. The manner of proceeding corresponds to importing screens as described in the previous section.

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9.4 How to create a new curve window

As with the screens, creating a new curve window can be accomplished in either of two ways.

1. Directly by means of the main menu
   Within this interface, it is possible to create or modify a curve window relatively easily during "running" operation.

2. With the aid of the Curve Window Assistant
   The Curve Window Assistant is an easy-to-use graphical interface specially designed for setting up screens quickly and easily. To use it, however, it's necessary to call the Assistant separately.

Both options have their advantages and disadvantages. The two methods are described below.

9.4.1 Directly creating and modifying curve windows

To create a new curve window, start by clicking on the menu item "Curve window – New" and in the dialog which then appears enter a name for the new screen. A new entry will then appear in the Project Explorer under the heading "Curve window". The screen name may have a maximum length of 29 characters.

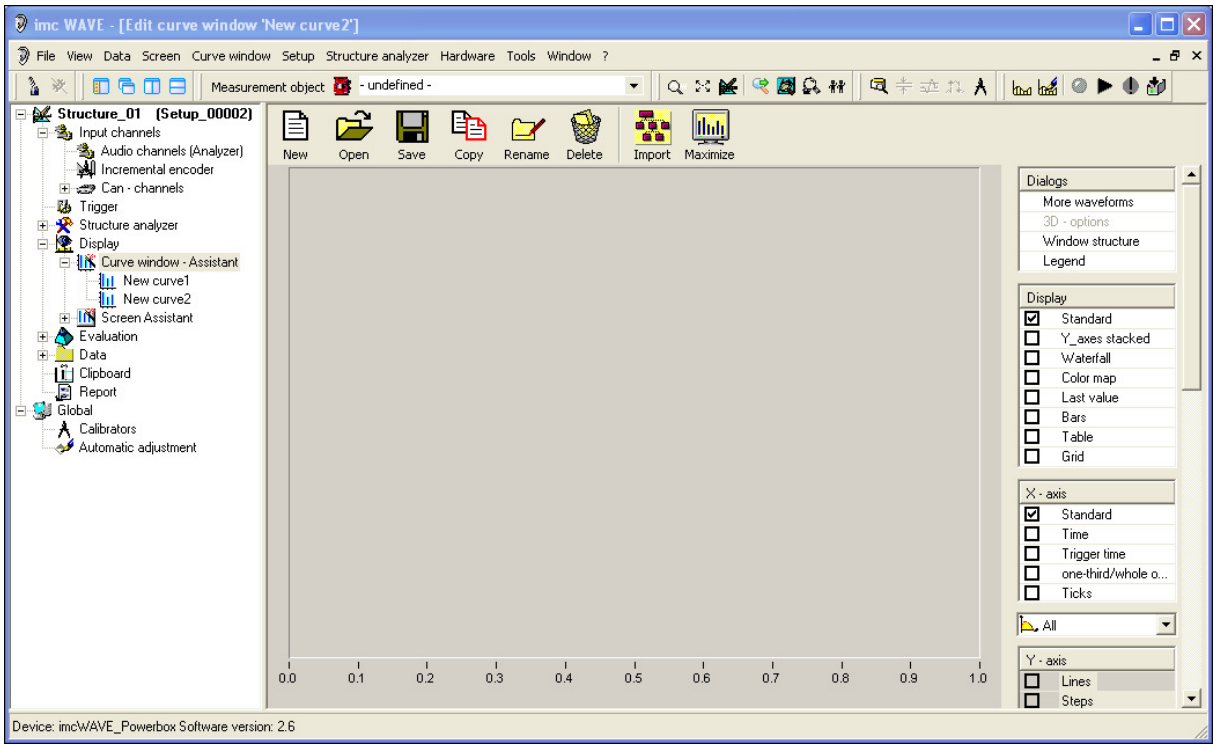

Fig. 39: Creating a new curve window

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You can now adapt the appearance of the curve window to your wishes. To do this, you must plot some data in the window.

If you have not yet carried out any measurement, then first prepare a measurement so that there will be empty data sets to display. If you have completed measurements, choose data to display.

Once you have made your choice, access the menu item "Curve window – More Waveforms...".

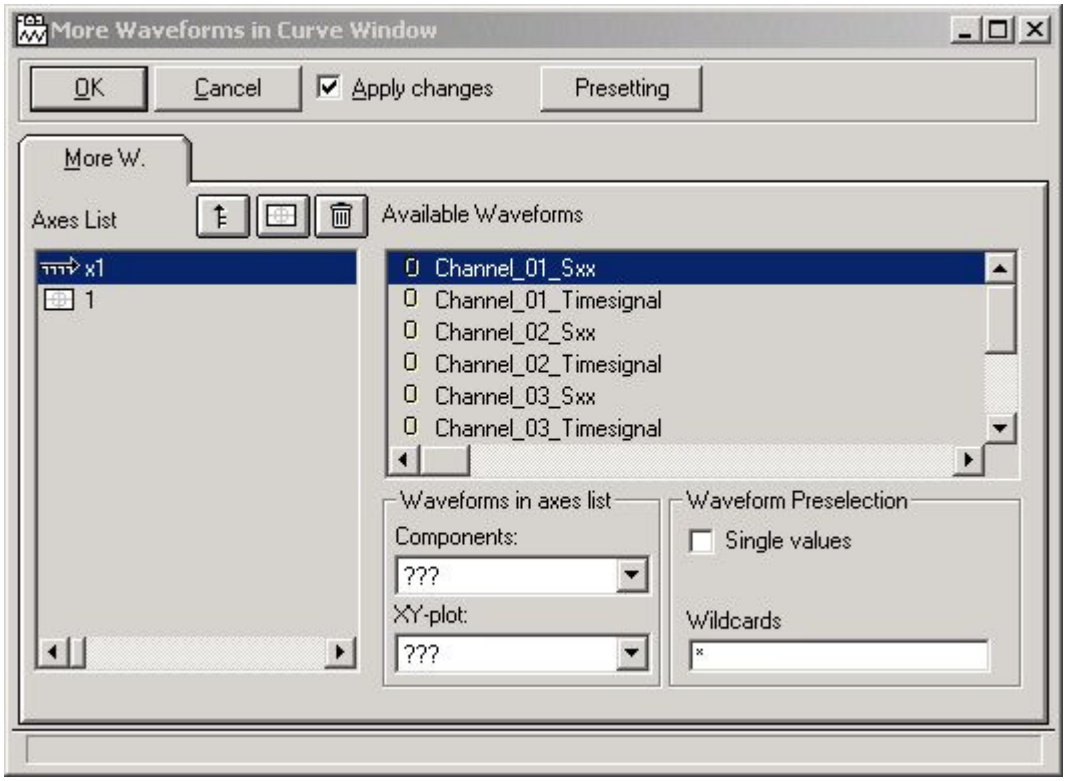

Fig. 40: More waveforms ...

In the dialog which then appears, you can add data from the right-hand list by means of Drag & Drop into the left-hand list. All waveforms listed at left are displayed in the curve window. If, for instance, you have selected the waveforms F_Terzen_Out1 and F_Terzen_Out2 and drop them in the list at left, then close the dialog with "OK", the curve window will appear as shown below.

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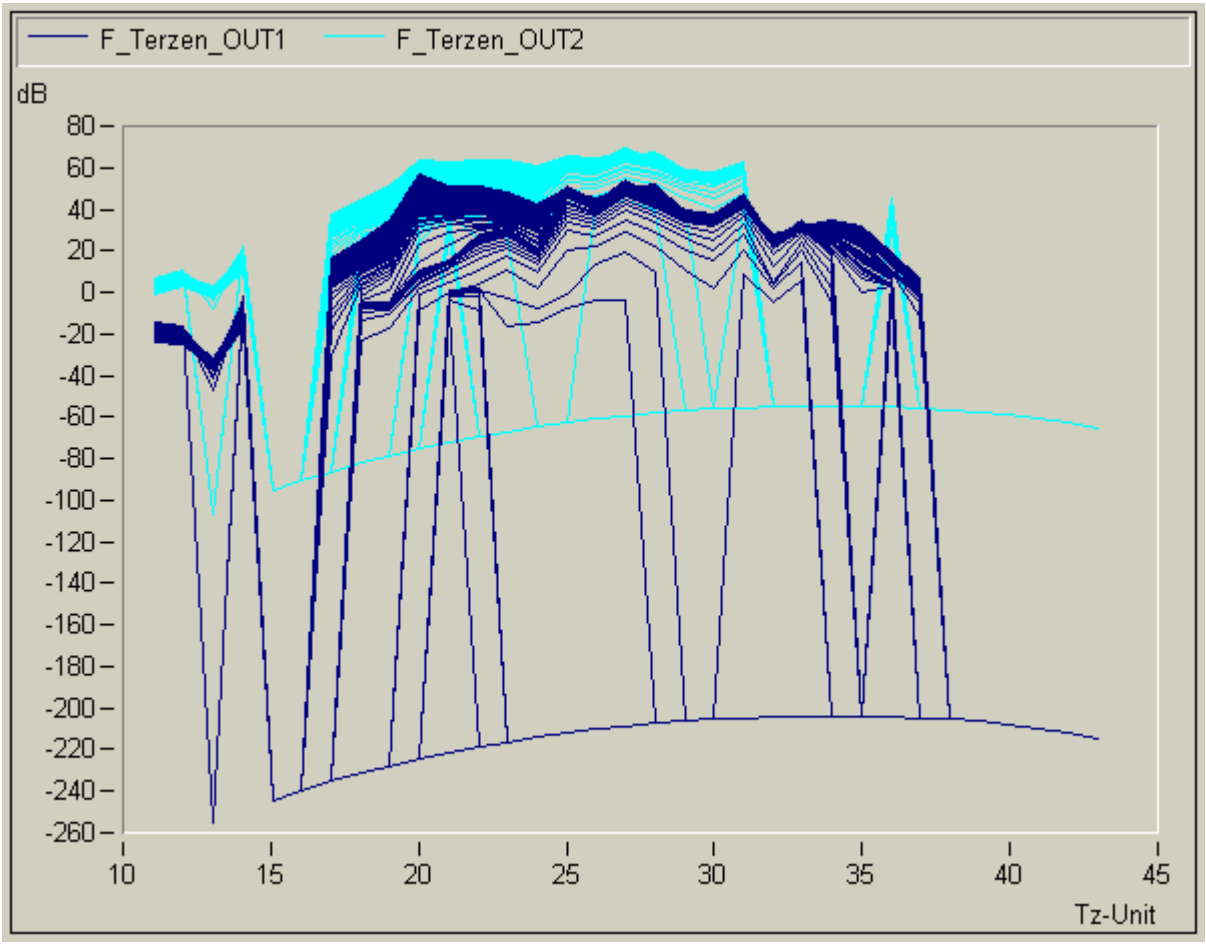

Fig. 41: Newly configured curve window

Now that we have changed the curve window's configuration, we will save the changes. To do this, access the menu item "Curve window – Save". For details on configuring the curve window, refer to the manual "imc-Curve Manager".

9.4.2 Working with the Curve Window Assistant

The Curve Window Assistant is started by double-clicking on the entry "Display – Curve Window Assistant" in the Project Explorer. This calls the following dialog:

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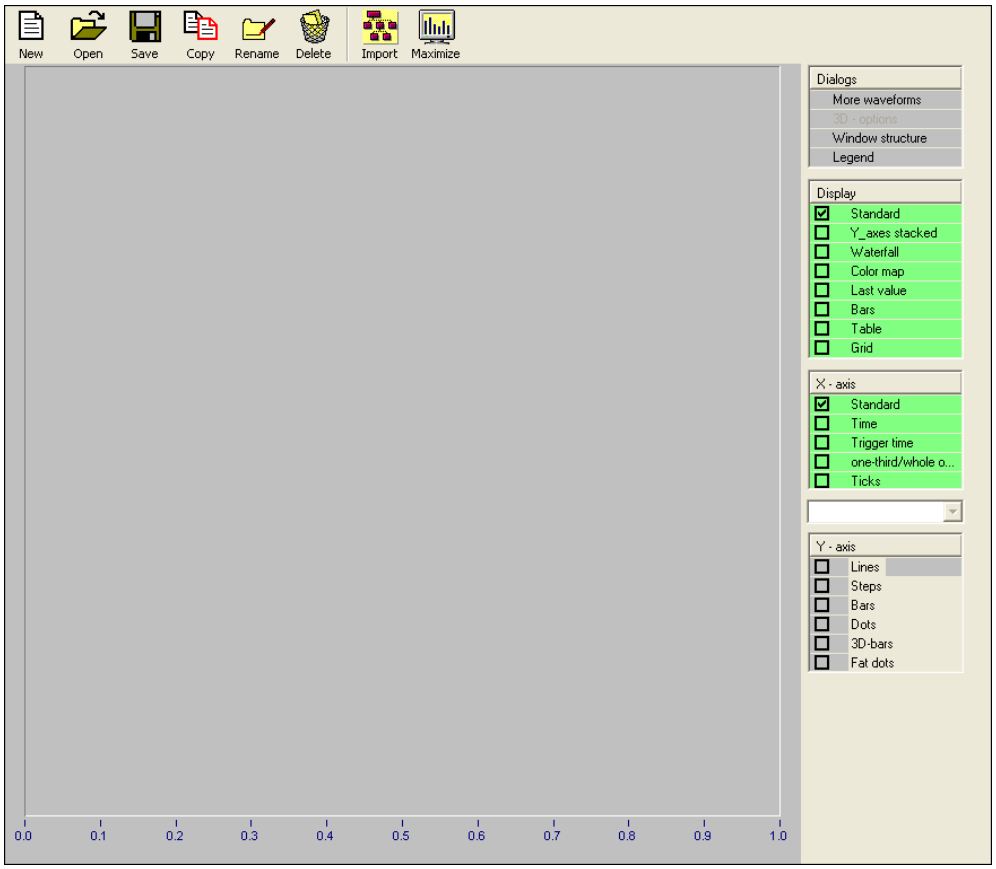

Fig. 42: Dialog of the Curve Window Assistant

The dialog consists of a curve window in which the desired modifications can be made, plus a toolbar and several list boxes at the curve window's right edge.

Using the toolbar at the top of the workspace, the curve windows can be loaded, saved, displayed, etc.. The list boxes each offer a group of related functions.

To create a new curve window, click on the toolbar button "New"

. You will be prompted to supply a name for the curve window to be created. Enter the name desired into the dialog's input box. Then you can modify the newly created curve window as desired. To do this, first select the entry "More waveforms" from the "Dialogs" list box. In the dialog which then appears, you can drag whichever waveforms you wish to the curve window. Details on working with the curve windows are provided in the manual "imc Curve Manager". Once you have dragged the curves into the dialog and have assigned the data to the appropriate axes, the dialog could appear as follow:

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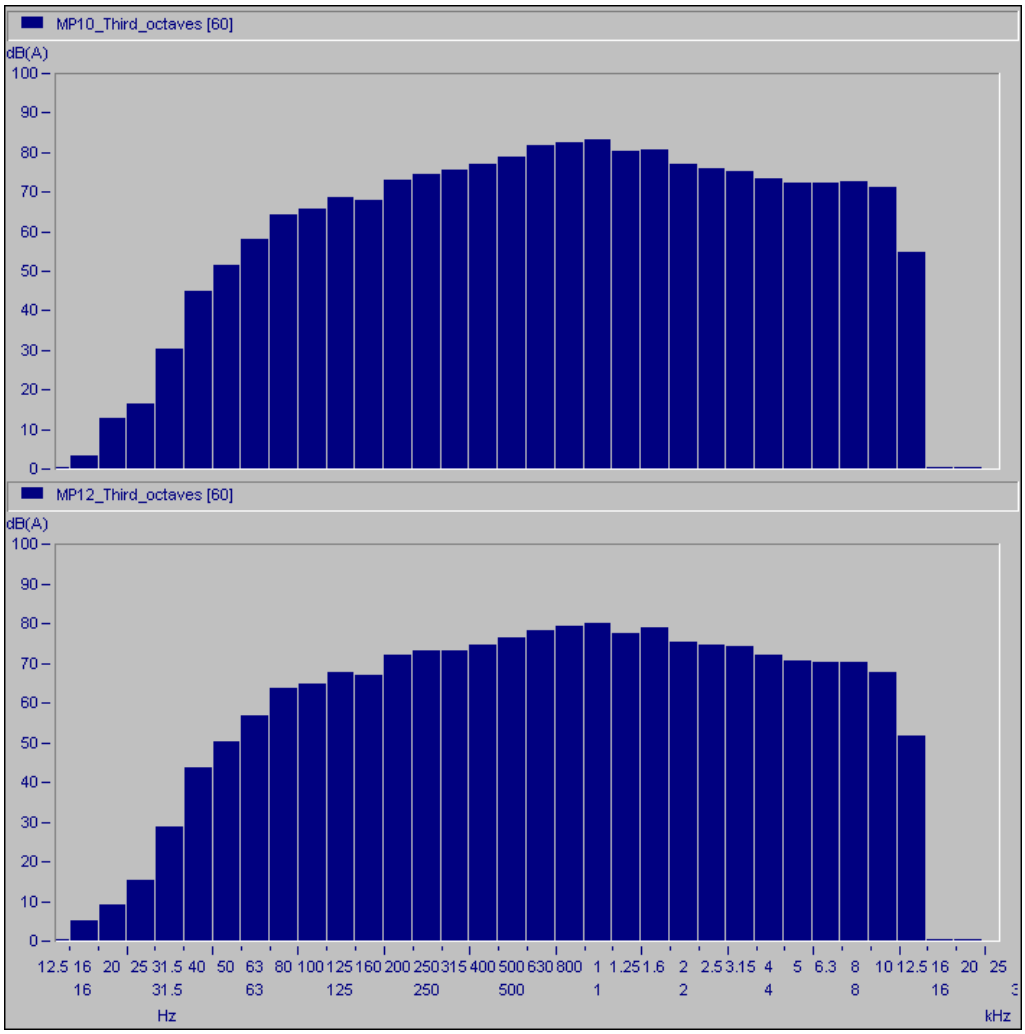

Fig. 43: Curve window modified in the Curve Window Assistant

You can also place a grid in the curve window. To do this, select the entry "Grid" from the "Display" list box. The curve window then appears as follows.

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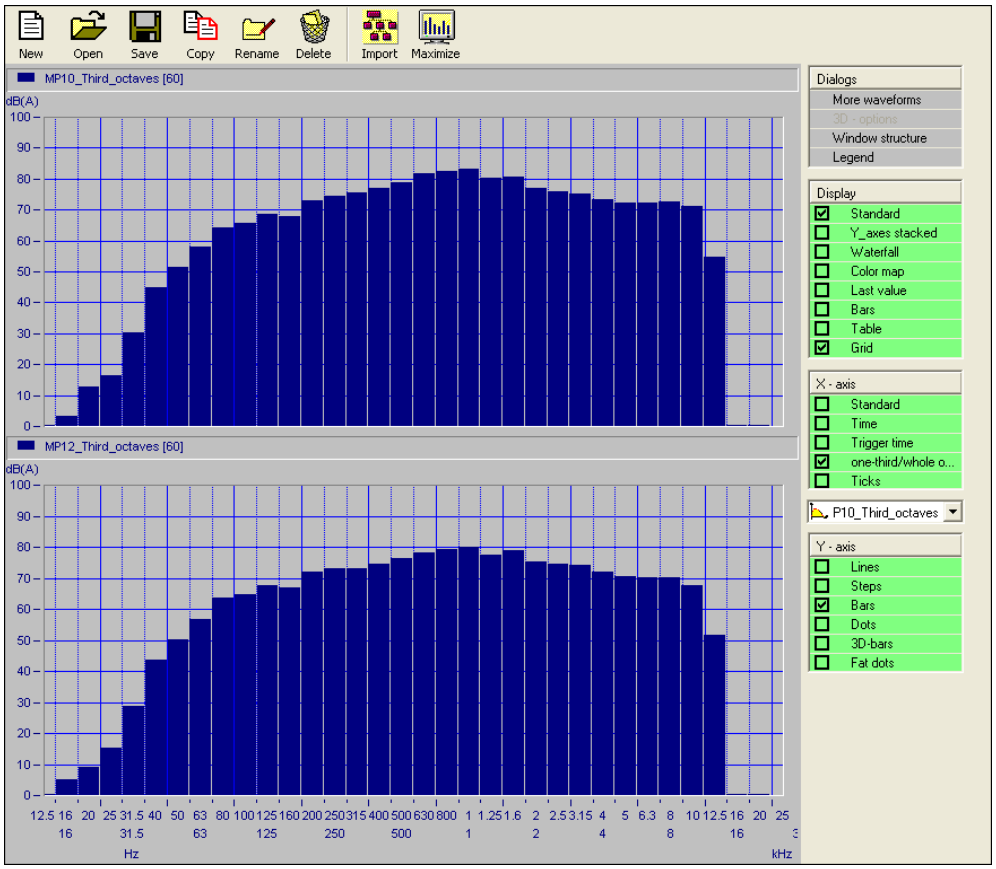

Fig. 44: Curve window with superimposed grid

Now it's also possible, for example, to change the display style of the second curve by choosing to display the curve as a line diagram instead of as a bar chart. To do this, select from the combobox the curve "P12_Third_octaves" and change the option in the list "Y-axis" from "Bar graph" lines. The curve window should then appear as follows:

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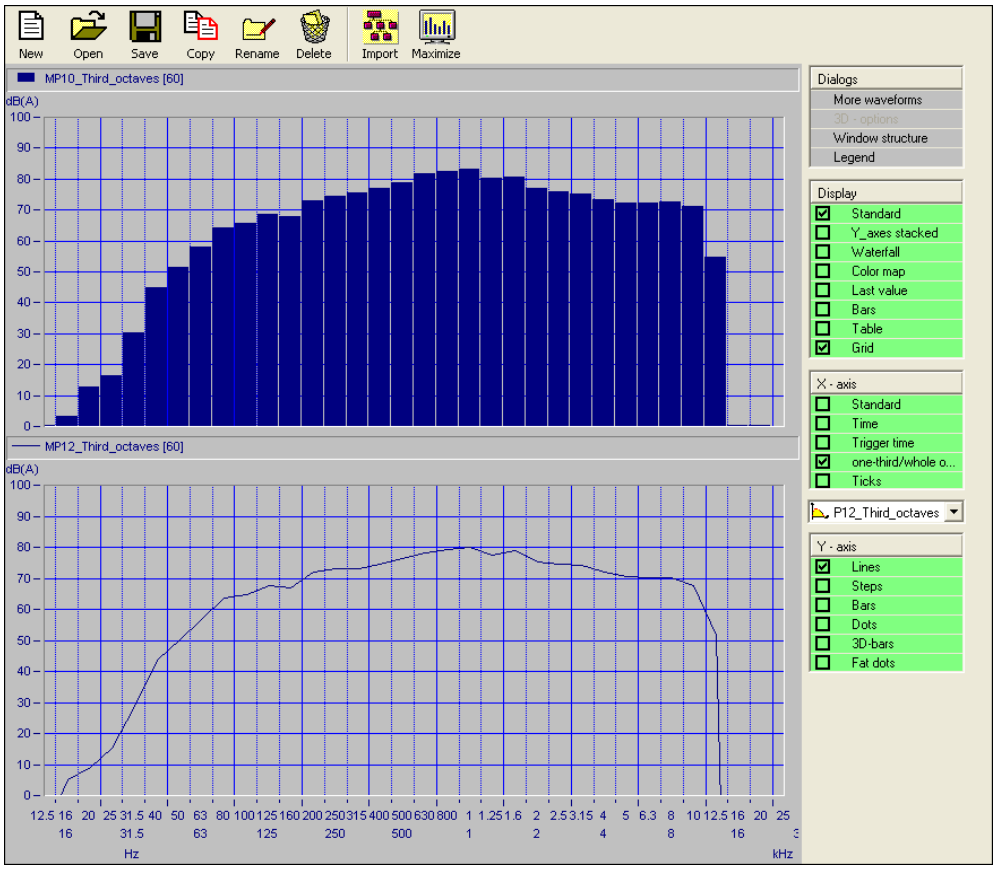

Fig. 45: Curve window with the second curve's display style changed

Following this procedure, it is now possible to carry out a large number of changes directly via the list boxes. All of the curve window's functions can be accessed by right-clicking the mouse over the curve window. The dialog which then appears offers the complete range of functions.

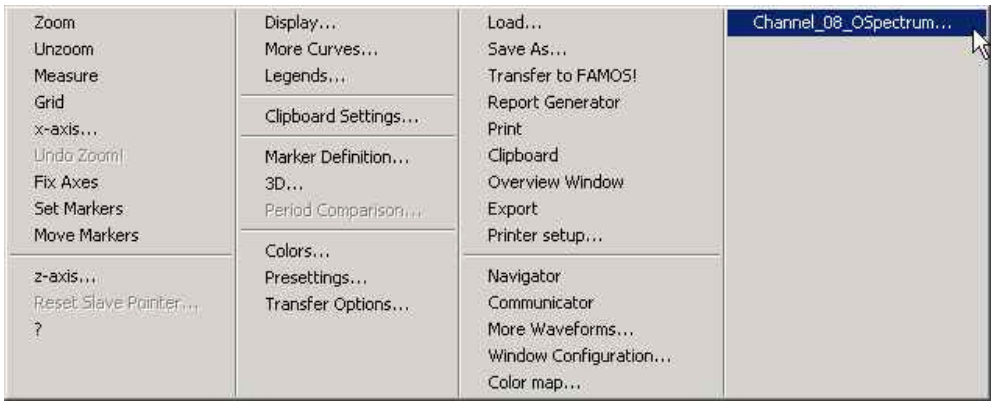

Fig. 46: Dialog with the total spectrum of curve window functions

Once you have adapted the curve window according to your requirements, you can save it by means of the toolbar button "Save".

The Curve Window Assistant's toolbar also offers the following functions:

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Copy
This tool lets you duplicate the current curve window. After copying, you work actively in the copy.

Rename
It's also possible to rename the current curve window. Enter the new name into the input box of the dialog which appears.

Delete
This button can be used to delete the currently active curve window. Before deletion occurs, you will be prompted to confirm your intention.

Import
Import of curve windows is described in a separate section of this chapter.

Maximize
If you wish to view the current curve window in a screen without a toolbox, use the button "Maximize". Then a new screen is automatically created in which the curve window appears.

9.5 How to import screens and curve windows

If you wish to import screens from other projects, access the menu item "Screen – Import".

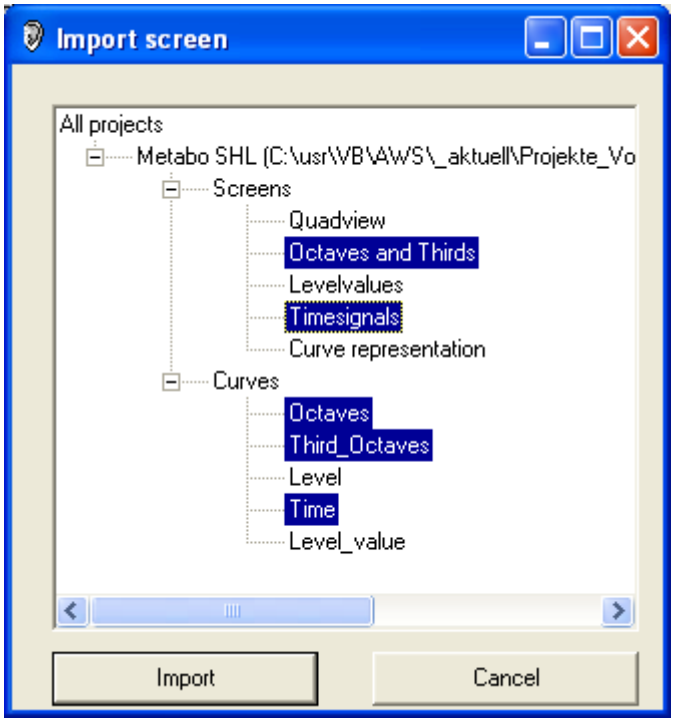

Fig. 47: Importing screens and the associated curve windows

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A dialog appears displaying a tree of the current projects. From the tree you can select the entries of screens you wish to use in the current project. The curve windows associated with the selected screens are automatically activated and imported with the screen. But you can also select curve windows manually and add them to your current project.

Once you have selected all desired objects, close the dialog by clicking on the button "Import". Now the desired objects are available to your current project.

9.6 Using screens and curve windows in concert

We can now assign a new curve window to a screen. To do this, first select the desired screen in the Project Explorer. A screen can contain 1 – 4 curve windows (depending on the partitioning). You can click on one of these curve windows (which causes the window to be framed in black) and assign the curve configuration you just made to the curve window. This is done by left-clicking the mouse over the curve window created, then dragging it to the desired target curve window and dropping it there by releasing the mouse. The target curve window's configuration is automatically replaced by the newly created and saved configuration.

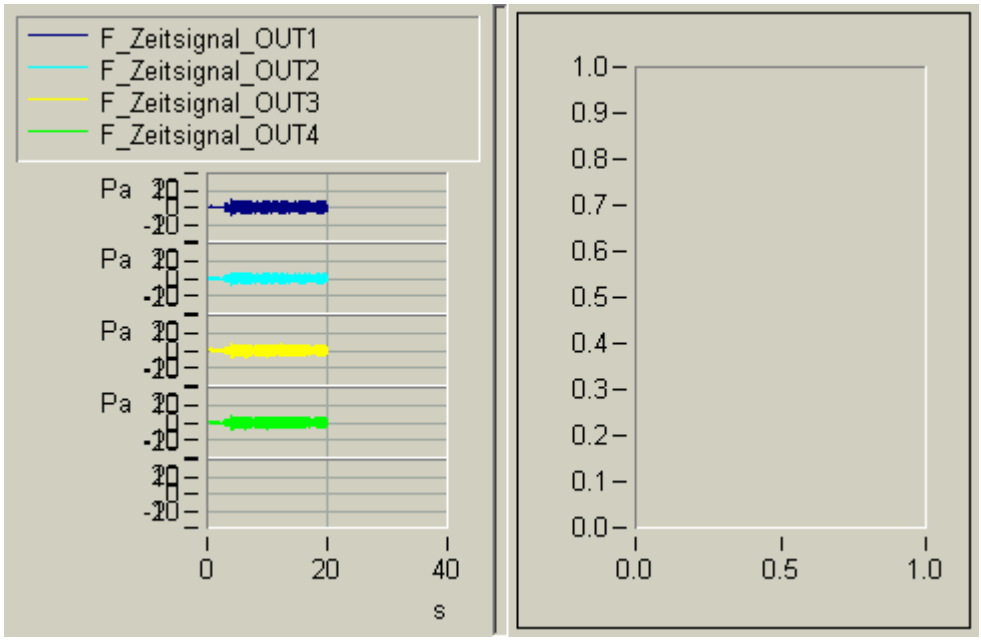

Fig. 48: Screen before configuration assignment

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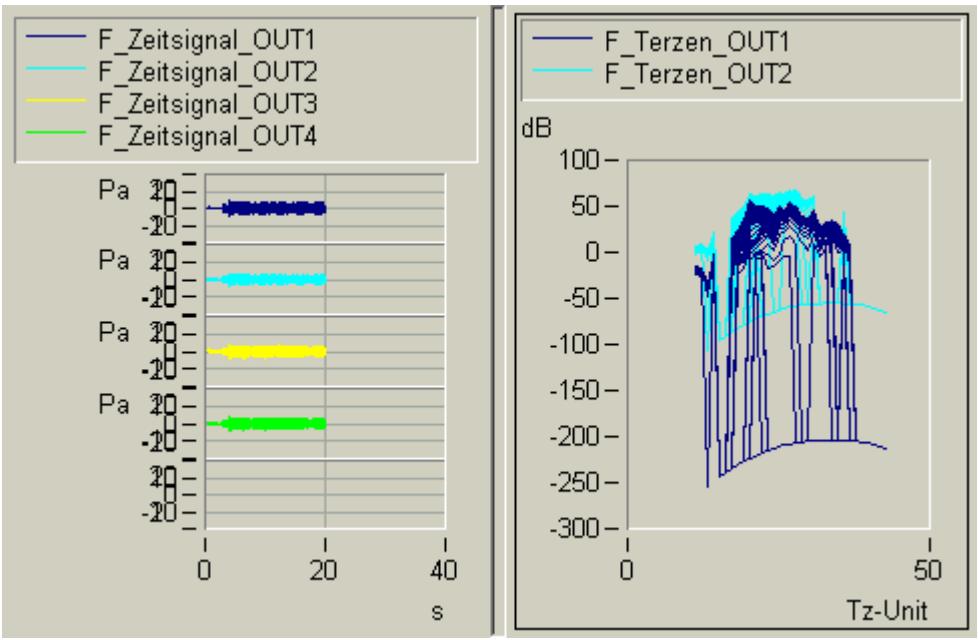

Fig. 49: Screen after assignment of the new curve configuration

The altered screen must be saved to make the changes permanent.

Now you are familiar with the basic workings of screens and curve windows. The possibilities for varying the interface are unlimited. Refer to the corresponding chapter in the manual "imc-Curve Manager" for more information.

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10 Measurement Data

Till now, the project has been characterized only by its configurations and display settings. We still need to introduce data.

imc WAVE has two kinds of data sources

1. online measurement data from the measurement device
2. stored measurement data

These two sorts are treated equally and can be displayed in any desired arrangement or order.

10.1 How to display on-line data from the measurement device

Once the configuration has been completed as described above, it is time to prepare for measurement. Select the menu item "Hardware – Preparation"

To learn what is required for hooking up with the measurement device, please refer to the device documentation.

Now, imc WAVE loads the desired configuration to the measurement device and prepares the measurement process. After this preparation, measurement can begin. Select the menu item "Hardware – Start".

Measurement then starts in accordance with the valid settings; the measurement data are streamed from the measurement device to the PC and displayed by imc WAVE in the prepared screens.

You can switch between screens during a running measurement and thus display the data in a variety of ways.

If you configured the measurement to end at a fixed point in time, measurement will stop automatically, otherwise use the menu item "Hardware – Stop".

Measurement is then complete and the data can be viewed in the screens provided for the purpose.

10.1.1 How to save on-line measurement data

The on-line data can be saved automatically or manually.

To have data saved automatically at the end of a measurement, activate the menu item "Data – Archiving – Automatic". The checkmark in front of the menu entry indicates that automatic archiving is active.

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If automatic archiving was not activated, the last measurement can be saved by accessing the menu item "Data – Archiving – Last measurement". However, the last measurement is only available for saving until new data are loaded or acquired.

10.2 How to display stored measurement data

Stored measurement data are indicated in the Project Explorer under the heading "Data". A new entry is posted for each measurement performed. There are three choices for how a measurement entry can be designated:

- **Number**
  A measurement's number within a project. The number is unique within a project and can only be assigned once. This means that numbers once deleted are gone forever.
- **Name**
  A freely assigned name which can have up to 29 characters.
- **Date**
  The date upon which the measurement was performed.

All three styles exist alongside each other and can be exchanged at any time. Changing the designation type is accomplished using the menu item "Data – Display".

Display of the data is called by simply double-clicking on the entry in the Project Explorer for the corresponding measurement. The data are automatically loaded in the background and assigned to the currently active screen.

You have the option of viewing the data in different screens by activating the screen desired. Or you can view different data in the same screen by activating different data.

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10.3 How measurement data are administered

Measurement data are administered through the use of the "Data" menu. In addition to the options already mentioned, the following functions are also provided:

- Data overview display
- Data deletion
- Copying of data to the Clipboard
- Data grouping

10.3.1 Data overview display

The data overview display provides an overview of all of a saved measurement's parameters, some of which can be edited.

Nr	Name	Date	Setup	Path	Folder	Measurement object	Comment
1	2004-07-20 15-16-12 (1)	20.07.2004 15:16:	Setup_00002	\Daten	2004-07-20 15-16-	Firebird	
2	2004-07-20 15-16-20 (2)	20.07.2004 15:16:	Setup_00002	\Daten	2004-07-20 15-16-	Volvo	
3	2004-07-20 15-16-28 (3)	20.07.2004 15:16:	Setup_00002	\Daten	2004-07-20 15-16-	Volvo	
4	2004-07-20 15-16-37 (4)	20.07.2004 15:16:	Setup_00002	\Daten	2004-07-20 15-16-	- undefined -	

Fig. 50: Data overview display

The following parameters are shown:

- **Number**
  unique ID number for measurement (not editable)

- **Name**
  Name of measurement (editable)

- **Date**
  Date of measurement (not editable)

- **Setup**
  Setup used in the measurement (not editable)

- **Path**
  Path along which the measurements are saved within the project folder (not editable)

- **Folder**
  Folder in which the measurement is saved (not editable)

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- **Measurement object**
  Assigned measurement object (to be selected from the list of measurement objects)

- **Comment**
  Comment for the measurement (editable)

10.3.2 How to delete data

The menu item "Data – Delete" can be used to remove data from a project. The data are at the same time deleted from the storage medium.

10.3.3 How to copy data to the Clipboard

Data from one or more measurements can be copied to the Clipboard where they are readily accessible for further display, independent of the measurement currently active. A detailed description is offered in the chapter on the Clipboard.

10.3.4 How to group data

imc WAVE provides the ability to organize measurement data hierarchically within the Project Explorer. Toward this end, data sets can be grouped.

You have the following possibilities

- **Create new groups**
  Menu item "Data – Group – New"

- **Close existing groups**
  Menu item "Data – Group – Close"

- **Rename an existing group**
  Menu item "Data – Group – Rename"

If you right-click the mouse over a measurement appearing in the Project Explorer, you can place the currently selected measurement into an already defined group by using the menu item "Move to". But you can also simply use the Drag & Drop mouse technique to place a measurement into a particular group.

In certain analyzers, grouping of data plays a special role; for instance, in sound power analysis, the production statistics are calculated by means of the groups.

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10.3.5 How to export data in different file formats

imc WAVE allows you to export data in different file formats.

To do this, select the menu item Data/Archiving/Export …

This opens the dialog for selecting the measurements to be exported in a different format.

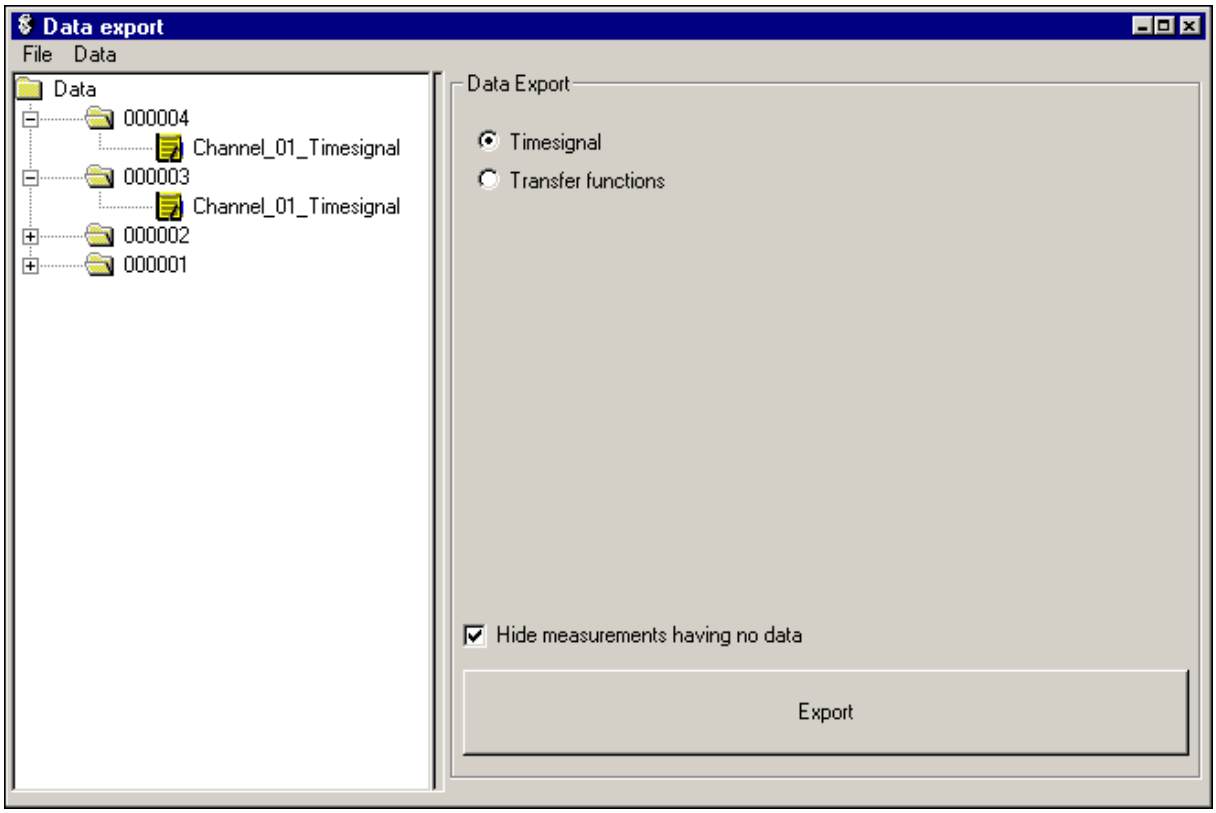

Fig. 51: Selection dialog for the data to export

With the help of this dialog, you can now select either

- all measurements
  Simply click on the tree entry "Data".

- single measurements
  Simply click on the tree entry for the desired measurement.

- or data sets form individual measurements
  Open the tree diagram entry by double-clicking on it or by a single click on the plus-sign to the left of the entry, and then select the desired data set in the sub-entry for the particular measurement.

On the right side of the dialog, there are yet more settings options. These include the default data sets to be displayed in the tree diagram. Here, you have a choice between transfer functions and time-based data. There

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is also a setting for hiding the display of measurements which don't contain data.

Once you have made your selection, you can then save the data in a different file format by pressing the button "Export". For this purpose, a file selection dialog appears in which you can enter the desired filename for the file to create.

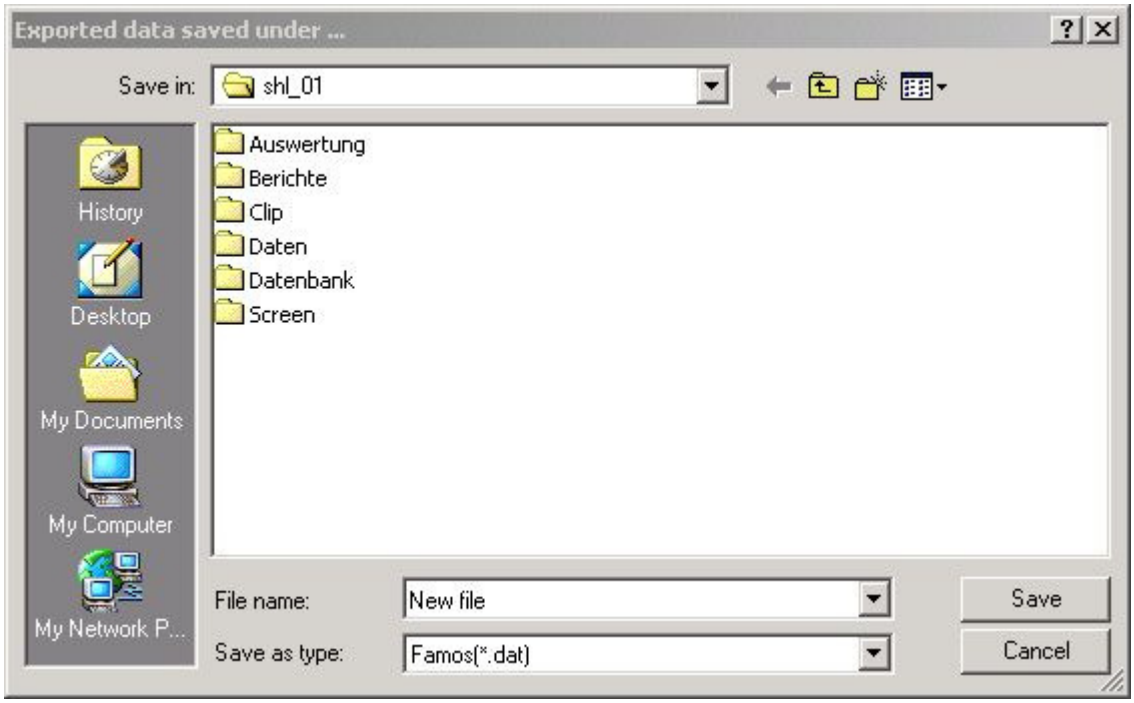

Fig. 52: Dialog for saving the data to be exported

Under "Filename", enter the file's new name, and under "File type", the file type in which to perform the export.

The following data types are currently available:

- ME´scope Blockfile
- FAMOS Multifile

Information on additional file formats is available upon request.

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11 How to Evaluate Measurements

Along with analysis using familiar imc products (FAMOS, LOOK, Report Generator), additional analysis options are available which can be called from within imc WAVE.

These analysis capabilities party operate independently or in direct conjunction with imc FAMOS. Use of the analysis options which work with imc FAMOS requires imc FAMOS to be installed and operational in your system.

Selection of analysis options is performed in the Project Explorer under the heading "Evaluation".

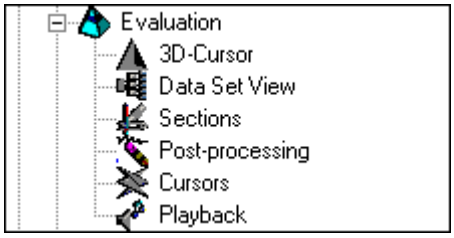

Fig. 53: Selecting an analysis option

The analysis options directly built in to imc WAVE provide direct access to data without the need for conversions, thus enabling quick analysis and a close look at data, even during measurement.

The functionality of the analysis is an integral part of imc's concept and uses the familiar tools such as curve windows and the Report Generator, which were mentioned above in connection with screens.

On the conditions stated above, the analysis options are available to any project. But the individual displays are specific to a particular project since they are directly associated with the particular data acquired.

The following analysis options are available:

- **3D-Cursor**
  Display of 3D-waveforms in Waterfall or color map representation, with the ability to take horizontal and vertical slices through the three-dimensional display. The data from the slices are displayed in their own curve windows.

- **Data set view**
  This is the option to display the individual measurement data of all measurements in one curve window, thus making it possible to

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compare corresponding data points from different measurements.

- **Sections**
  Calculation of new data sets from recorded measurement data. For the automatic analysis, the user can run a program of FAMOS sequences which he has created himself and parameterized. Any data generated by the sequences are available for printout or other evaluation.

11.1 The 3D Cursor

To call the analysis option "3D-Cursor", access the entry "3D-Cursor" under the heading "Evaluation" in the Project Explorer.

The dialog for the 3D cursor graphics consists of three curve windows. The left curve window can be loaded with the 3D data set which is derived from the measurement currently selected under the heading "Data". In order to load a data set into the curve window, select the menu item "View". Below the menu items "Color map" and "Waterfall", there are menu entries representing the data sets which can currently be loaded to the curve window. Select one of these entries, which will then be displayed in the left-hand curve window.

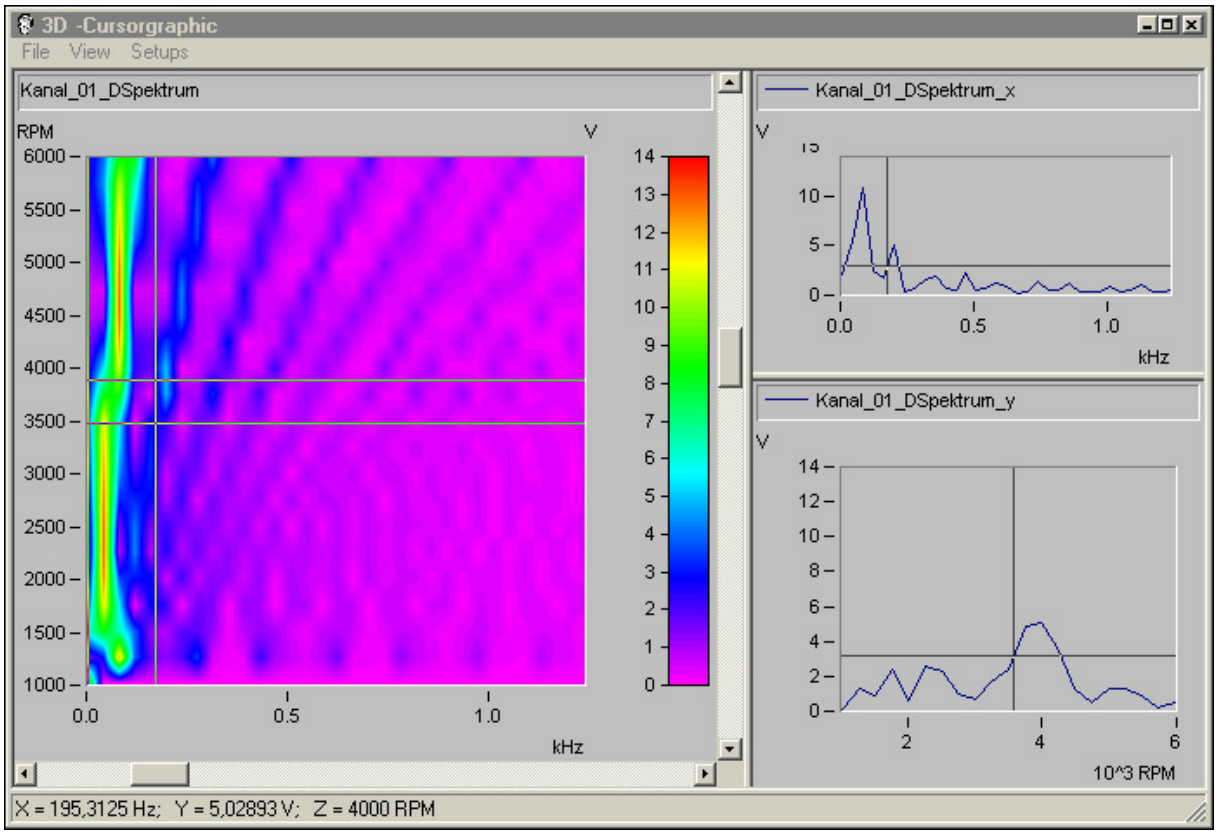

Fig. 54: Display of the 3D-cursor analysis as a color map

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You can now use the scroll bars at the button and right alongside the curve window to move the cursor through the data set; the curve windows on the right-hand side of the dialog show the cross sections of the map corresponding to the cursor position. The upper curve window shows a cross section in the X-direction while the lower one shows the section in the Y-direction.

The data set depicted here represents an RPM-spectrum recorded by the order analyzer.

Next, you can switch to the menu item "View – Waterfall" to view the same data in waterfall representation.

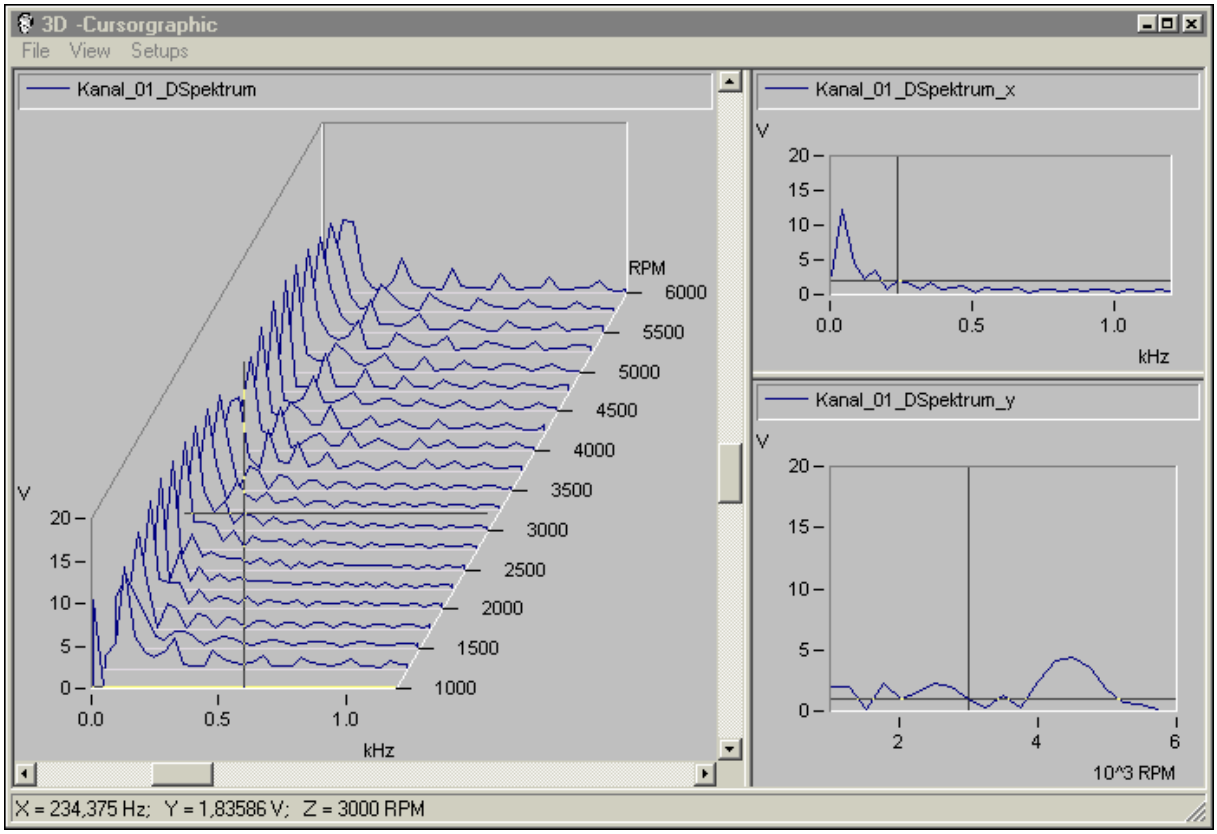

Fig. 55: Display of the 3D-Cursor analysis as a waterfall

In this display, also, you can scroll through the data set using the scroll bars at the window edges, and see the cross sections at the cursor positions in the other windows.

Besides the basic functions described, there are other settings options available under the "Settings" menu:

- **Show channel information**
  A channel comment appears in a box above the graph with the

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cursors.

- **Keep cursor position when switching**
  When switching to different data sets viewed, it is possible to keep the cursor at the same position and thus provide a quick way to compare data sets at corresponding locations.

- **Auto-scaling of cross sections**
  If this option is active, the cross sections are automatically scaled, meaning that the resolution is always optimal for the Y-axis of the curve window containing the cross section.

- **Synchronize cursor with cross sections**
  This option synchronizes the cursor in the 3D curve window with those in the cross section windows. The cross section cursor positions automatically change when the 3-D cursor moves.

The cursor coordinates are indicated in the dialog's status bar. By double-clicking on the status bar, you can open a dialog in which the values for the cursor's x- and y-coordinates can be entered directly.

To print out views of the data in the curve windows, you can either use the imc curve window's own direct interface or start the imc Report Generator and copy the curve window into it. For details, refer to the manual "imc Curve Manager and Report Generator".

11.2 The Data Set View

Call Data Set View by double-clicking on the item "Data Set View" under the heading "Evaluation" in the Project Explorer.

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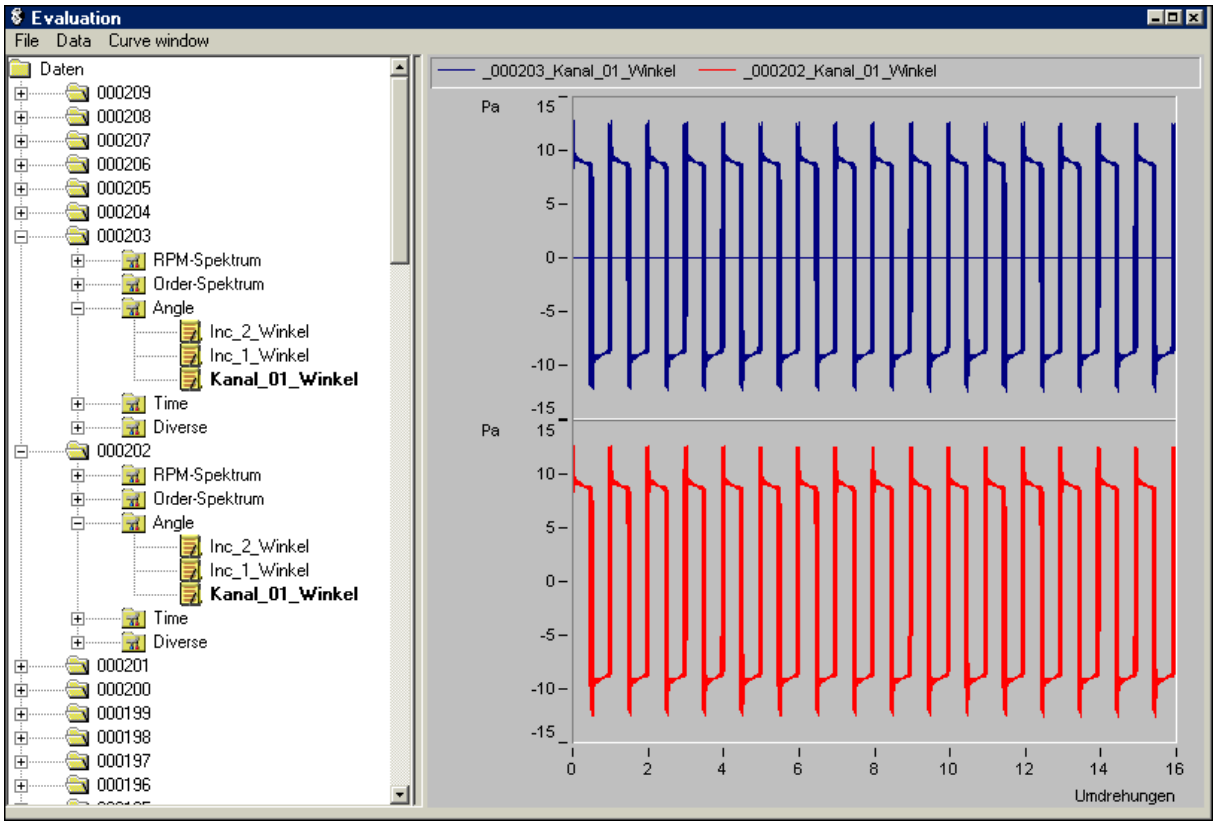

Fig. 56: Data Set View dialog

The left side of the Data Set View dialog contains a tree diagram of all available measurements. You can expand the individual measurement entries to reveal the individual data sets captured as part of a measurement.

Double-clicking on a data set's entry transfers the data set to the curve window in the dialog's right half. The data set's entry in the tree diagram then appears in boldface font. It is now possible to transfer other data sets either from the same measurement or from others into the curve window, so that it is possible visually compare various data with each other.

In addition to the basic functions there are a number of other options for handling data as well as displaying data in the curve window. These options are described elsewhere; please also refer to the documentation for the imc curve window.

11.3 How Automatic Analysis works

Automatic Analysis provides an easy way to have a calculation performed or calculated data displayed in a curve window.

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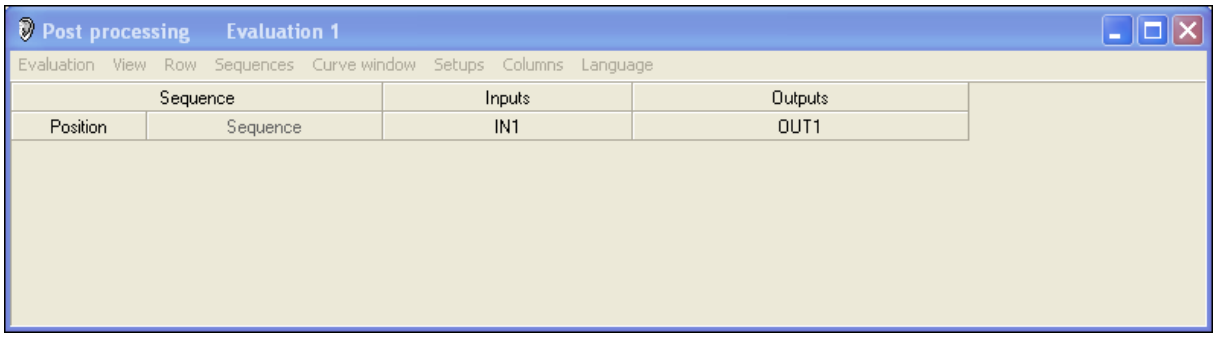

Fig. 57: Definitions dialog for "Automatic Analysis"

Automatic Analysis is defined as a series of imc FAMOS sequences carried out by imc FAMOS in a particular order. A working version of imc FAMOS is required to create and run such sequences.

To call the dialog for specifying an automatic analysis routine, double-click on the entry "Selection" under the heading "Evaluation" in the Project Explorer.

The objective is to define a series of FAMOS sequences and printing sequences. The FAMOS sequences use input and output channels. By means of the algorithm defined, the input channel's information is transformed into that of the output channel.

Using the functions under the menu "Columns", you can add new input or output channels or delete existing ones. You must state the maximum number of input and output channels you require. However, you need not configure all of the input and output channels for every sequence. For instance, if you have a sequence requiring only one input channel, just leave the entries for the other input channels empty. Then, only the first input channel will be transferred.

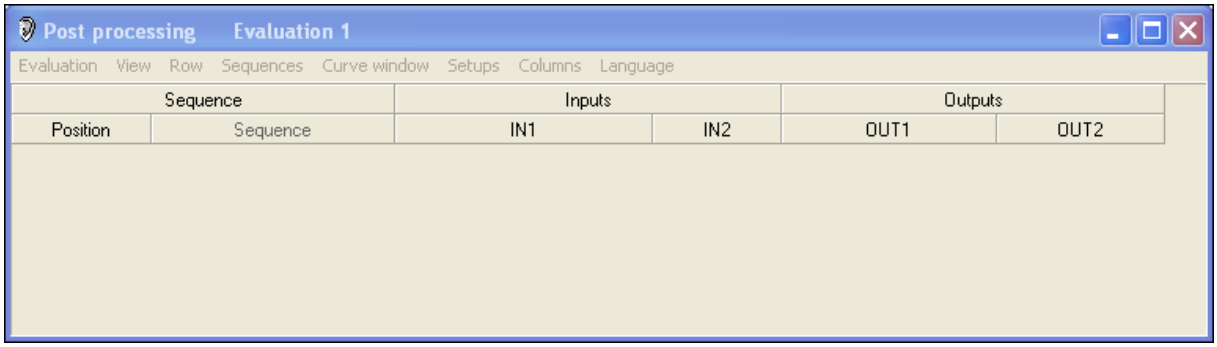

Fig. 58: Example of an analysis with two input and output channels each

Before you can design the analysis program, you must create a FAMOS sequence. There are two ways to do this:

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1. Define a free sequence
2. Define a section

Both options are based on imc FAMOS sequences.

11.3.1 Defining a free sequence

You can generate a free sequence by selecting the menu item "Sequences – New". In the dialog which then appears, enter a name for the sequence to be created. This sequence is first opened in imc FAMOS automatically and then stopped right away with an intentionally arranged error message.

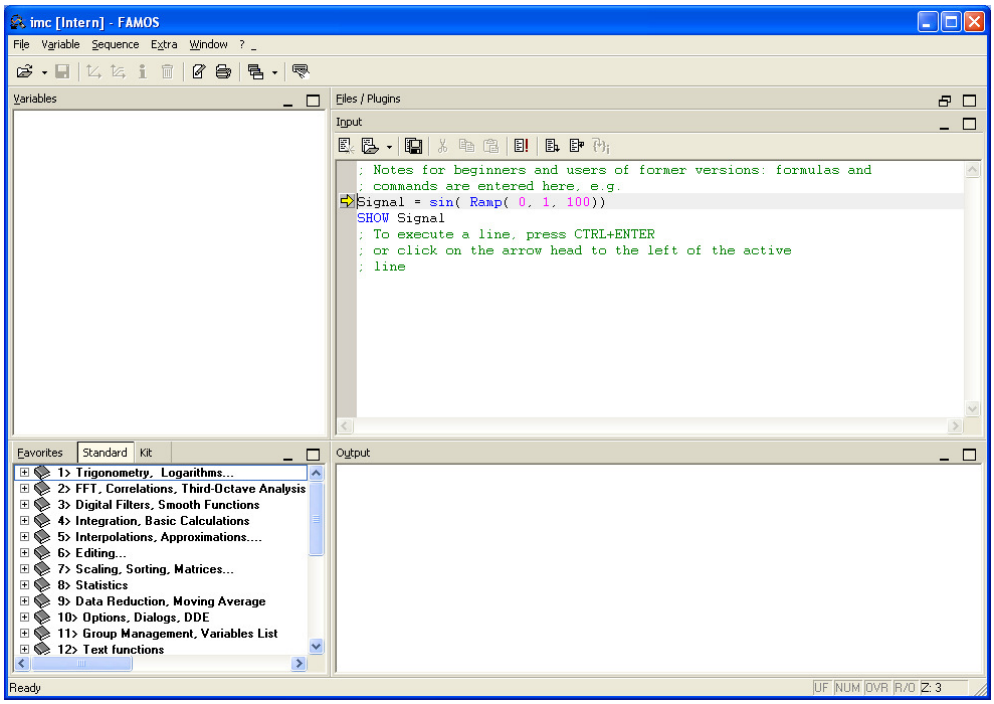
imc [Intern] - FAMOS
File Variable Sequence Extra Window ? _
Variables
Files / Plugins
Input
; Notes for beginners and users of former versions: formulas and
; commands are entered here, e.g.
Signal = sin(Ramp(0, 1, 100))
SHOW Signal
; To execute a line, press CTRL+ENTER
; or click on the arrow head to the left of the active
; line
Favorites Standard Kit
1> Trigonometry, Logarithms...
2> FFT, Correlations, Third-Octave Analysis
3> Digital Filters, Smooth Functions
4> Integration, Basic Calculations
5> Interpolations, Approximations....
6> Editing...
7> Scaling, Sorting, Matrices...
8> Statistics
9> Data Reduction, Moving Average
10> Options, Dialogs, DDE
11> Group Management, Variables List
12> Text functions
Output
Ready
UF NUM OVR R/O Z: 3

Fig. 59: imc FAMOS with the opened sequence

The sequences work with so-called standardized names. The input channels are designated IN1, IN2, IN3, etc.. The output channels are entitled OUT1, OUT2, OUT3, etc.. You thus have the option of using the sequences you created with any input or output channels without needing to rewrite them. Imc AWS takes care that the data are correctly assigned to the input and output channels.

Once you have written the sequence, save it under the name specified and in the folder specified. Only on these conditions does imc WAVE have any chance of finding the sequence again.

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11.3.2 Defining a section

Before you can begin to define the analysis program, you must create a FAMOS sequence. To do this, select the menu item "View – Sequence definition".

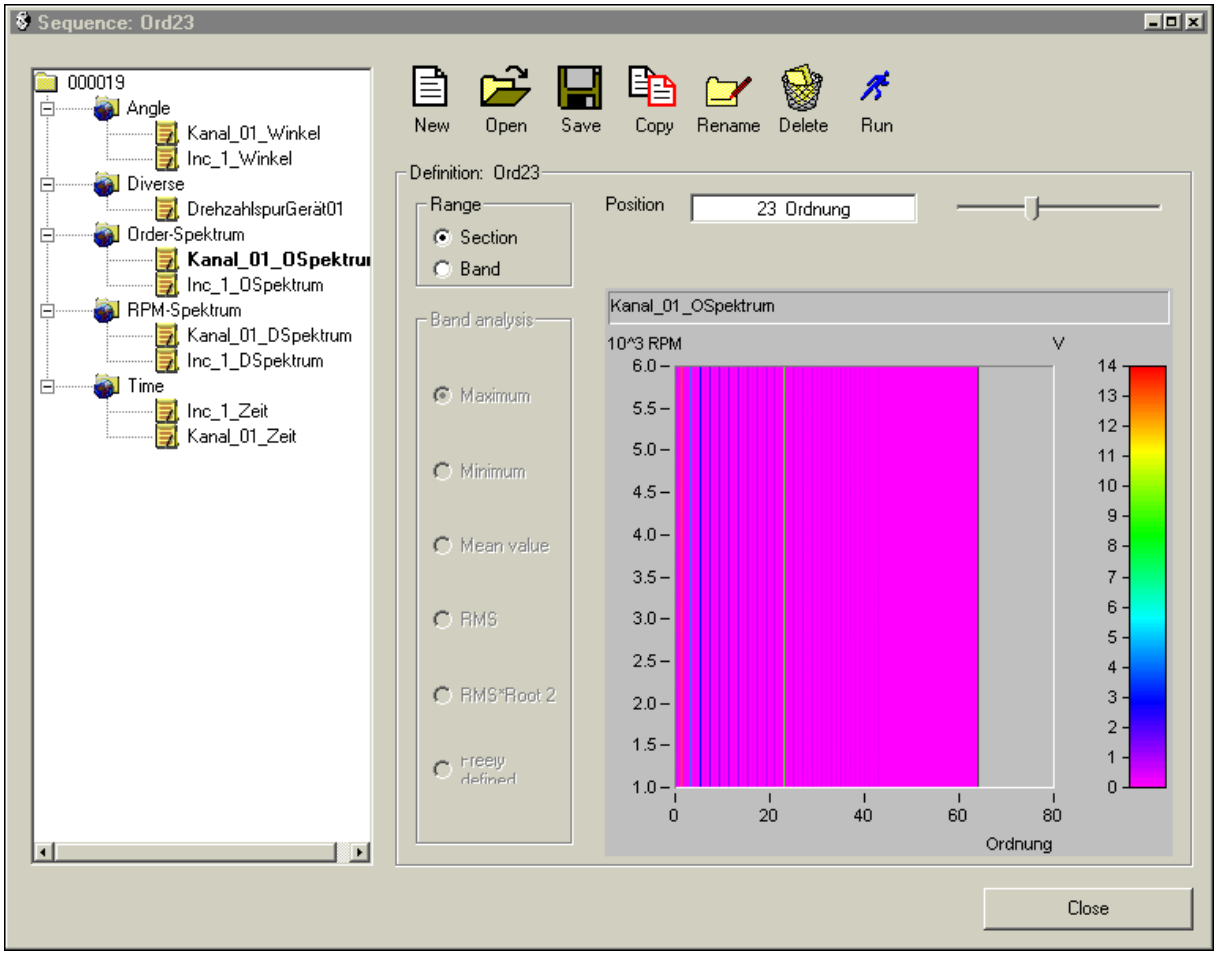

Fig. 60: Definitions dialog for creating sequences

To create an imc FAMOS sequence, choose an input data set from the list on the left side of the dialog which appears as displayed above. This is done by clicking in the little box next to the channel's entry. The data set is transferred into the curve window. There is a choice between making a section through the data, and clipping a band out of the data which is then condensed into a section.

In both cases you use either the cursor in the curve window or the sliders above the curve window to select the data range to be processed.

To obtain a section, select a section line and enter a name for the sequence to be created. By pressing the "Create" button, the sequence is saved. You can now test the sequence by pressing "Run". The data returned are displayed in a curve window after processing.

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If you choose to clip out a band from the data, you are also able to set how the data in the band are compressed to a single value.

The algorithms available are:

- **Maximum**
  The maximum value of the data set within the band is determined.

- **Minimum**
  The minimum value of the data set within the band is determined.

- **Mean value**
  The mean value of the data set within the band is determined.

- **RMS**
  The RMS value of the data set within the band is determined.

- **RMS * SQRT(2)**
  The RMS-value of the data set within the band is multiplied by the square root of 2.

- **free definition**
  The user can define the algorithm using imc FAMOS functions.

Select the desired evaluation technique for the band and create the sequence to employ it. Then close the sequence definition dialog.

11.3.3 Creating a program of FAMOS sequences

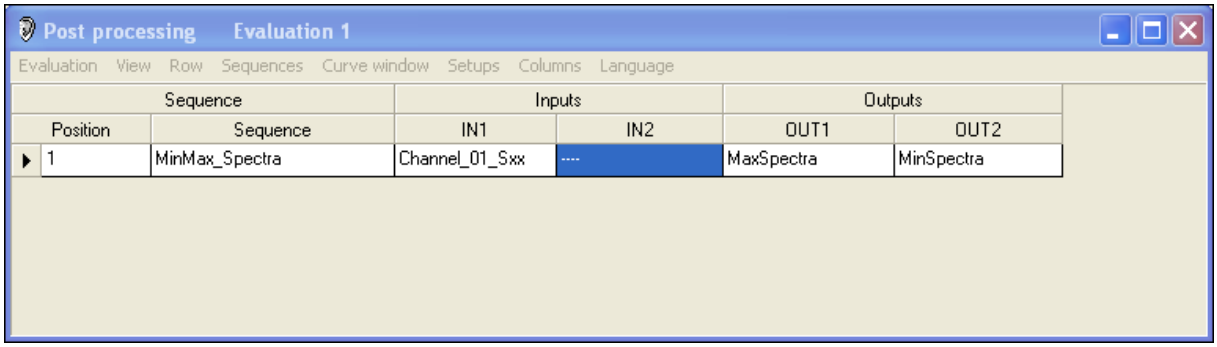

Fig. 61: Example of a program for automated analysis

In the selection dialog, you can insert the sequences created into the analysis program. To do this, select the menu item "Row-Paste". A new line which is to be filled is added to the table in the dialog.

This is done by selecting one of the sequences defined from the list under heading "sequence". Next select an input channel from the list under the

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next heading, and then enter a name for the output channel in the appropriate table cell.

Continue to proceed in this manner until you have completed the analysis program intended.

As well as imc FAMOS sequences, commands for creating lab reports can also be inserted. Such a report is set up and configured in the Project Explorer. The report appears in the list under "Sequence" appended to the testing program.

This completes the process of defining the analysis program.

Now you can test the analysis program. To do this, select the menu item "Evaluation – Check Evaluation" in the Automatic analysis dialog. A syntax check of the analysis program is performed and remedies are suggested if a bug is found. If the syntax check finds no errors, you can run the program by selecting the menu item "Evaluation – Run".

The data needed for the analysis are now transferred to imc FAMOS and the sequences involved are started. When processing is completed, the output channels are read in by imc WAVE and saved.

You can view the calculation results in the dialog by selecting the menu item "View – Curve window". The calculated data are then automatically plotted in the dialog's curve window.

You can now create more analysis programs or exit the dialog.

Once you exit the dialog, you can later apply the analysis routine to any desired measurement. To do this, select a measurement, and then from the "Evaluation" list in the toolbar the analysis routine. You can choose whether to perform the analysis with or without printout; in the latter case report printout is suppressed even if it is included in the program you made. The third icon in the toolbar is for editing the analysis program.

Fig. 62: Starting the automatic analysis program from the main dialog

The data from an executed analysis routine are to be found in the folder for the current measurement under the name you specified. The data are automatically loaded when the measurement is selected and are available for display in a curve window.

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The functions described above thus enable you to derive any desired quantities from the measurement data.

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12 The Clipboard

The Clipboard is a cache for measurement data and/or FAMOS data sets. The Clipboard can be used to keep data available for display regardless of which measurement is currently selected. This offers you the following capabilities:

- Comparison between data of different measurements
- Loading of tolerance curves and comparison of them with the measurements
- Storage of prototype data.

The Clipboard contents are a property of a specific project. The data are saved within a project and are available to the same project whenever it is loaded.

12.1 How to copy data into the Clipboard

The Clipboard has its own entry in the tree diagram of the Project Explorer.

You can copy data into the Clipboard or import data into it from imc FAMOS, for example, as a file.

Loading data
To load data to the Clipboard, right-click over the "Clipboard" entry in the Project Explorer and select the item "Load from file" from the context menu which then appears. This calls a file selection dialog.

Transferring data
There are different ways to transfer data to the Clipboard:

1. Select the menu item "Data – Copy to Clipboard" and from there, one of the measurements listed in the subsequent sub-menu.

2. Right-click over the Project Explorer entry for a data set, which is reached by expanding the directory tree under "Data" and is denoted by a name or ID number. From the context menu which then appears, select the menu item "Save curve(s) to Clipboard".

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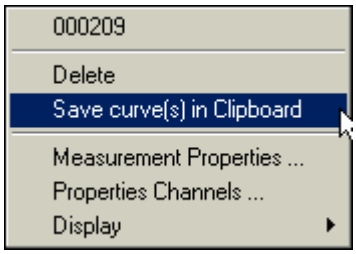

Fig. 63: Copying measurement data from the data directory

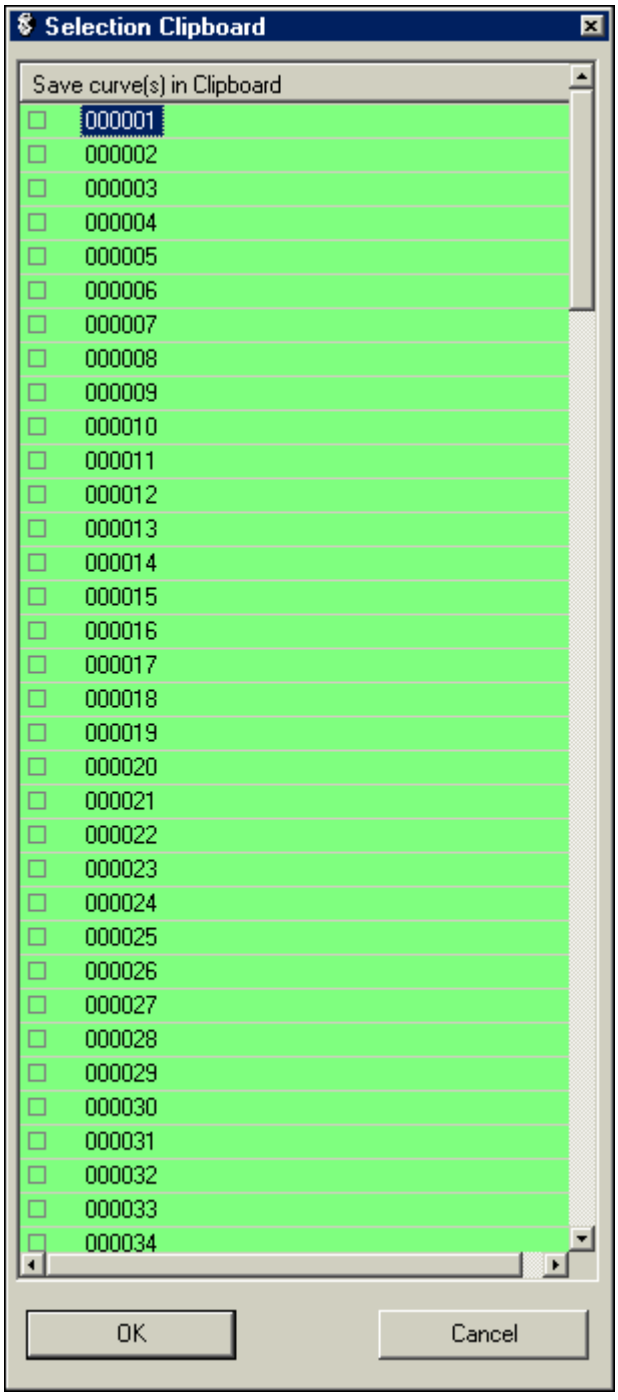

Fig. 64: Copying data into the Clipboard via the "Data" menu

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In each case, a dialog opens in which you can select the data sets you wish to transfer to the Clipboard. Closing the dialog with "OK" transfers the curves to the Clipboard.

Data located in the Clipboard can be displayed in any curve window. You can place data sets into a curve window straight from the Project Explorer by means of Drag & Drop. The data in the Clipboards is then automatically plotted in the curve window. Once the data is there, the full range of options offered by an imc curve window is then available for manipulating the display of the Clipboard data.

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13 The Report

imc WAVE comes with an extensive desktop publishing system realized in the imc Report Generator. For an exact description of the imc Report Generator, refer to the included manual. There you will find all relevant information on creating, administering and printing out Report templates.

We will now discuss using the Report Generator in conjunction with imc WAVE.

Lab reports are an integral component of imc WAVE. imc WAVE offers the ability to create and administer report templates and to control the contents of printouts.

Reports are created and administered as specific properties of a project.

13.1 How to create new reports

Reports are administered in the Project Explorer under the heading "Report".

Fig. 65: Administering reports in the Project Explorer

To create a new report, right click over the heading "Report" in the Project Explorer, next the item "New" from the context menu which then appears, and then and select either of the menu entries

- Empty
  to create an empty new report,

- Screen
  to create a copy of the screen currently selected.

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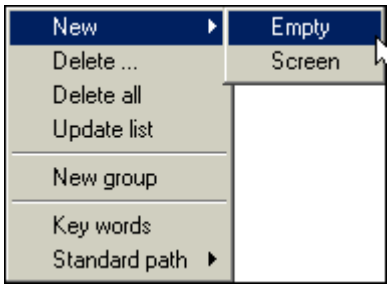

Fig. 66: Creating a new screen

A new entry having a default name is added to the Project Explorer and the imc Report Generator is started with the template.

The second method of creating a new report enables you to achieve a printable presentation of the screen content in a short amount of time.

The first method, on the other hand, is a more elaborate and versatile technique for creating your own personal layout. You can make reports to meet your own particular requirements. For this purpose, the imc Report Generator provides a large number of tools and options. Refer to the imc Report Generator's documentation to find the many examples which will be instructive for working with it.
Below is shown an example of a report specially prepared for use with imc WAVE.

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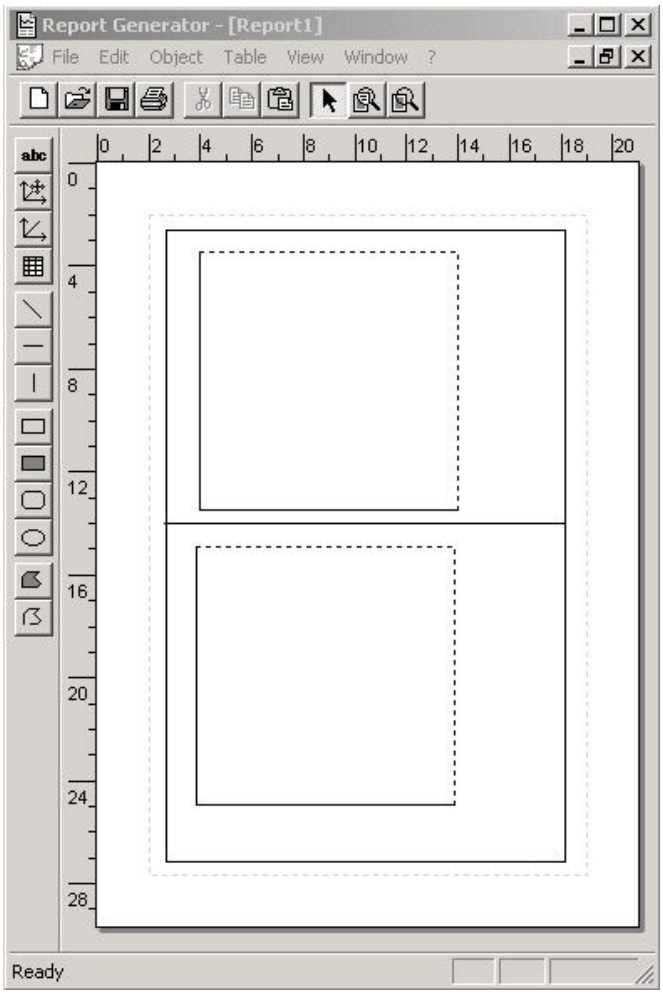

Fig. 67: Example of a report with curve windows and text elements

Text boxes, curve windows, frames and lines have been placed and aligned in this report.

Next, a link must be made between the report's elements and the structural elements of the respective imc WAVE analyzer.

One illustrative example:

> Every measurement in imc WAVE is associated with a name, a date and a comment. These data on the measurement can be included in the print layout. Whichever measurement you print out, the data corresponding to it appear in the report. For this to happen, the report needs to "know" what to print in which space. Thus, the report needs some information, an "address" so to speak, identifying the desired element. Just as a mailman knows by a house's address which letter to place in which mailbox, imc WAVE recognizes an identifier on every report element to be filled, and consequently transfers the appropriate data into it.

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For this purpose, imc WAVE provides a list of the "Addresses". Right-click on the heading "Report" in the Report Generator and select from the context menu the item "Keywords".

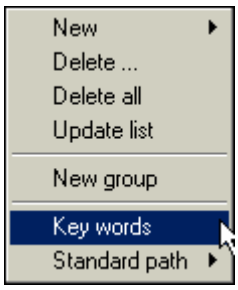

Fig. 68: Activating the list of keywords

The dialog with keywords defined for the current analyzer.

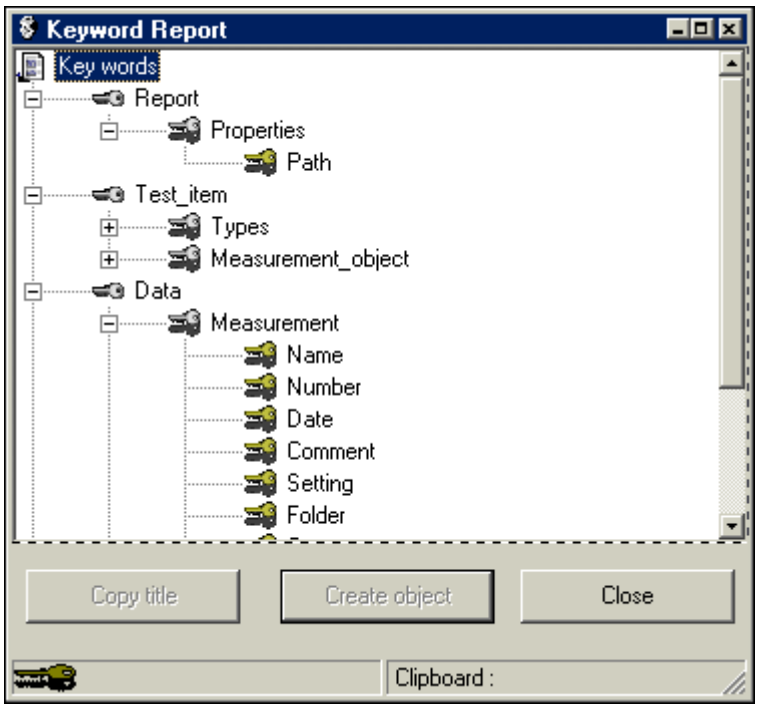

Fig. 69: Reserved keywords for the Report Generator

The keywords can now be individually assigned to the report elements. Proceed as follows:

1. Within the Keywords dialog, highlight the entry for the element you wish to display in the report, e.g. "Data – Curves – New Curve1". This is a curve configuration which was prepared for the purpose of displaying data in a screen.

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2. Click on the button "Copy keywords",

3. Go to the Report Generator,

4. Right-click on a curve window you had inserted into the report; a context menu appears, in which you must select "Properties"

5. A dialog appears in which, under the index tab "Title", you enter the keyword as the title of this element.

Another option for linking elements of the report to the measurement or configuration data in imc WAVE is accessed via the button "Create object". This is done as follows:

1. Mark the entry of the item you wish to display in the report, e.g. Data – Curves – ccv time signal. This happens to be a curve configuration which was set up for displaying measured data in a screen.

2. Click on the button " Create object"

3. Switch to the Report Generator, where an element corresponding to the entry you selected was automatically created and assigned it's name as the title. Thus, you only need to take care of the display properties (e.g. font size) and the element's position.

Whichever of the two methods you have used, imc WAVE now knows that you wish to display the curve window in the report in the exact same way in which it appears on the screen.

For all elements of the report, proceed in an analogous manner until each element has been assigned the appropriate keyword as its title. Having done all this, definition of the report is complete. Save the report.

13.2 How to print out reports of particular measurements

Till now, we have discussed making a layout for a report, but not which measurement is portrayed in the report's elements.

To assign a particular measurement to the report, activate the desired measurement by double-clicking on the corresponding entry under the heading "Data" in the Project Explorer.

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Now right-click on the entry in the Project Explorers for the report you set up, which is under the heading "Report". The following context menu appears:

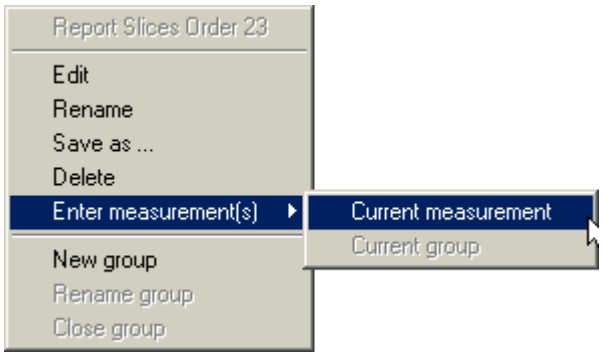

Fig. 70: Menu for inserting a measurement into a report

Select the menu item "Insert measurement". This instructs imc WAVE to load the report you set up, to fill all the report's elements with the data from the current measurement, according to the elements' keywords, and to format the entire report.

Here is an example of what a report could look like then:

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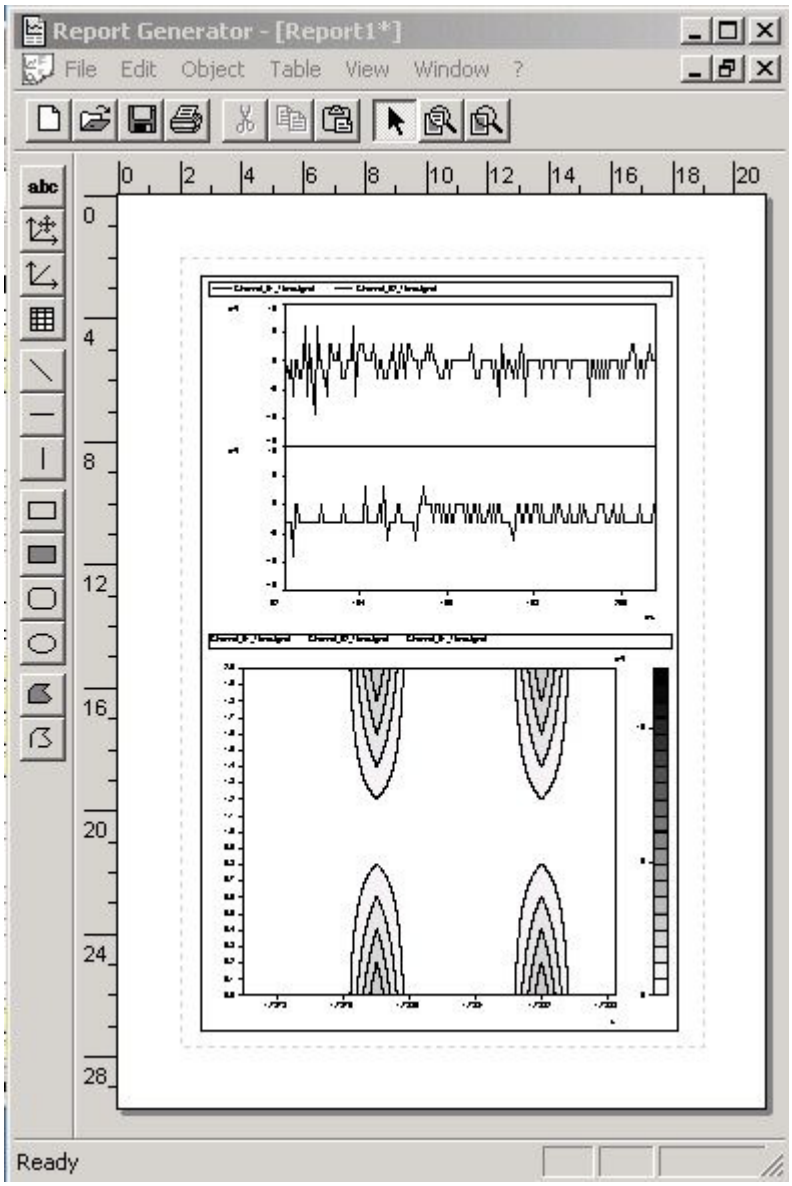

Fig. 71: Finished report with its elements filled

13.3 Can reports be administered in groups?

You additionally have the option to group reports together and to print them out as a group. To join up reports to a group, select the menu item "New Group". Then you can place all desired reports in the group using the Drag&Drop technique.

13.4 Can the same reports be used in different projects?

If you have some reports which are for use in multiple projects, you can work with a global folder. Reports are normally saved in a subfolder of a project. If you set the context menu item "Default path" to "Global", then in the selection dialog which opens subsequently, you can select a folder outside of the project which is thus accessible for other projects.

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14 Measurement objects

imc WAVE enables you to administer information on the measurement objects in a database and to directly link such information on the objects with their measurement data.

You may wonder what the advantages of such a capability are. Among others, it enables you to

- include the measurement object's properties with a printout of the measured data, and
- recognize what measurements were performed on which measurement objects.

For this purpose, imc WAVE provides a configurable database interface which can be adapted to meet your requirements.

The measurement objects are defined globally, outside the scope of any particular project, and are thus available for any project. Editing in the global measurement object database thus applies to all projects concerned.

The measurement object database is started by selecting the menu item "Tools – Measurement objects".

The dialog which then appears lets you make settings for the measurement objects.

A measurement object is fully defined in two stages, each having its own dialog:

1. Measurement object type
2. Components

A measurement object belongs to a type and consists of individual components.

Classifying the measurement objects in this way allows you to organize them into a hierarchical structure where the type groups all objects with common properties, and each object is composed of particular components.

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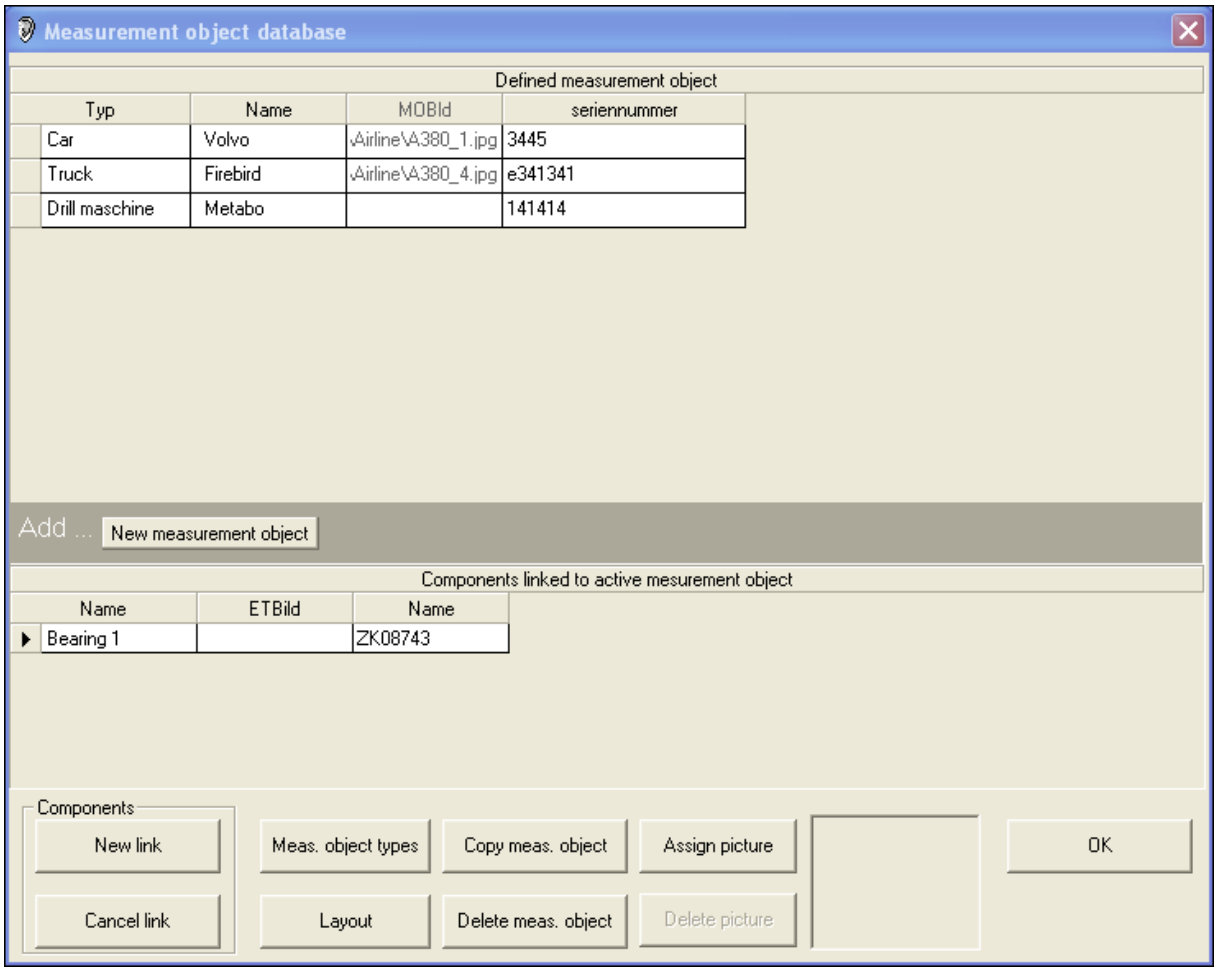

Fig. 72: Input dialog for measurement objects

14.1 How to edit the structure of a Measurement object database

Before entering data into the database, we must first adapt the database to our purposes.

To do this, we will edit the database's layout. Begin by pressing the "Layout" button.

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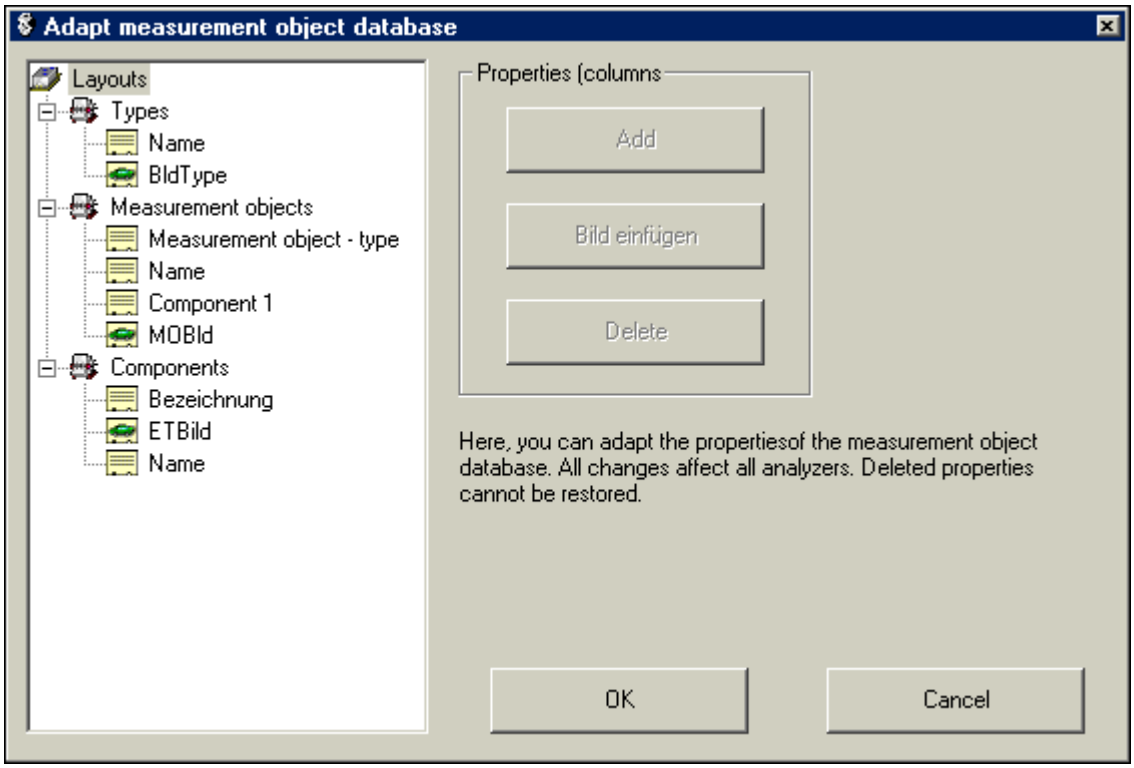

Fig. 73: Adapting the measurement object database layout

This dialog indicates what elements are currently available for each of the three dialogs Types, Objects, and Components. Each entry appearing under one of those three headings in the directory tree can be represented by a column in the database.
Later, you can use input dialogs to make entries under the columns.

There are two different kinds of entries in the tree:

1. **Entries with a red key icon in front**
   are so-called index fields and cannot be deleted since the database uses them for administration purposes and to relocate data.

2. **Entries without a red key icon in front**
   can be deleted since the database doesn't use them for administration purposes.

To illustrate:

> If you wish to make a new column in the Types database, first click on the heading "Types" in the directory tree. The button "Add" is enabled and you push it. Then you are prompted in a new dialog to enter a name for the new column. As a result, your entry will appear in the tree under the heading "Types".

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To delete an entry, select from the tree the entry to be deleted and press "Delete". Then the entry's icon appears crossed out in red.

All changes to the database only come into effect upon closing the dialog. You can discard any changes made by pressing the "Cancel" button. To exit the dialog while confirming the changes, press OK.

Now the layout should correspond to your wishes and we can proceed to discuss entering and assigning data.

14.2 How to define Measurement object types

Before we can define the object, we must define the types and components. Start by pressing the button "Object types". In the dialog which then appears, you can enter the desired types.

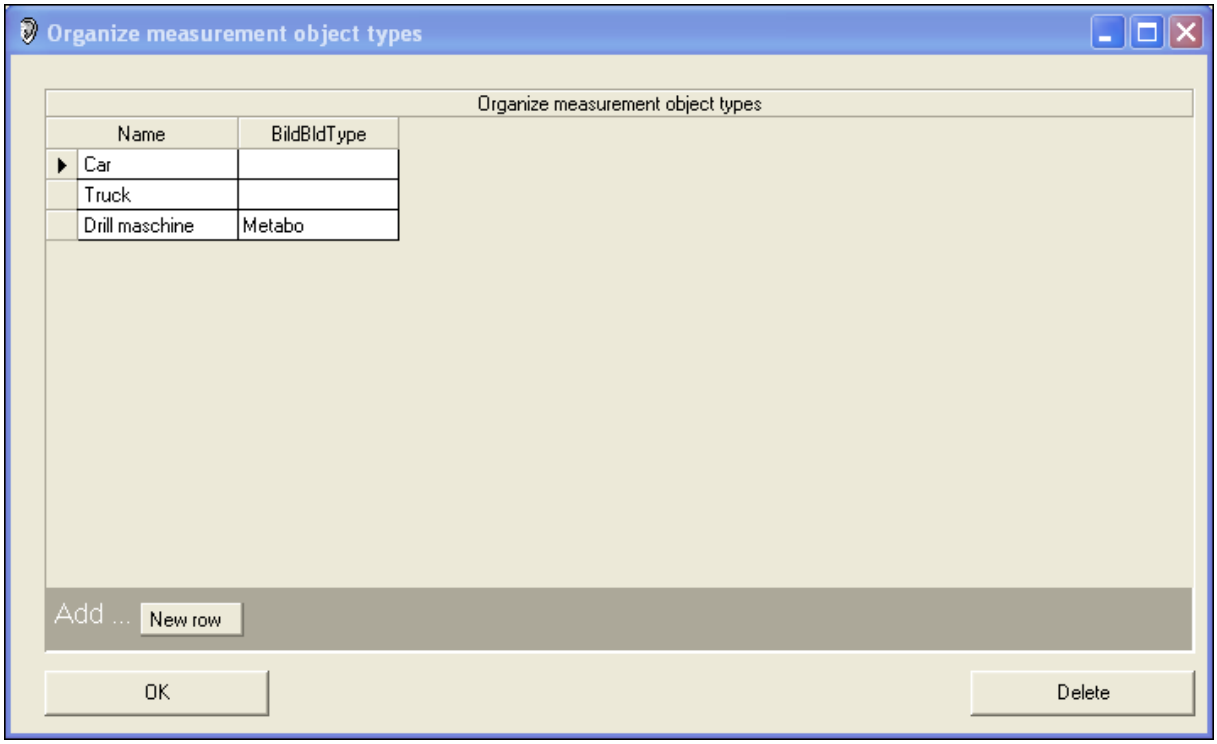

Fig. 74: Entering measurement object types

To set up a new type, press the button "New row". This adds a new row to the dialog which can be filled to suit your database design.

To delete a row from the table, select it and hit the "Delete" button.

Pressing "OK" closes the dialog and the edited types are available for further processing.

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14.3 How to define components

The next step is to enter the object components. To do this, start by pressing "New link".

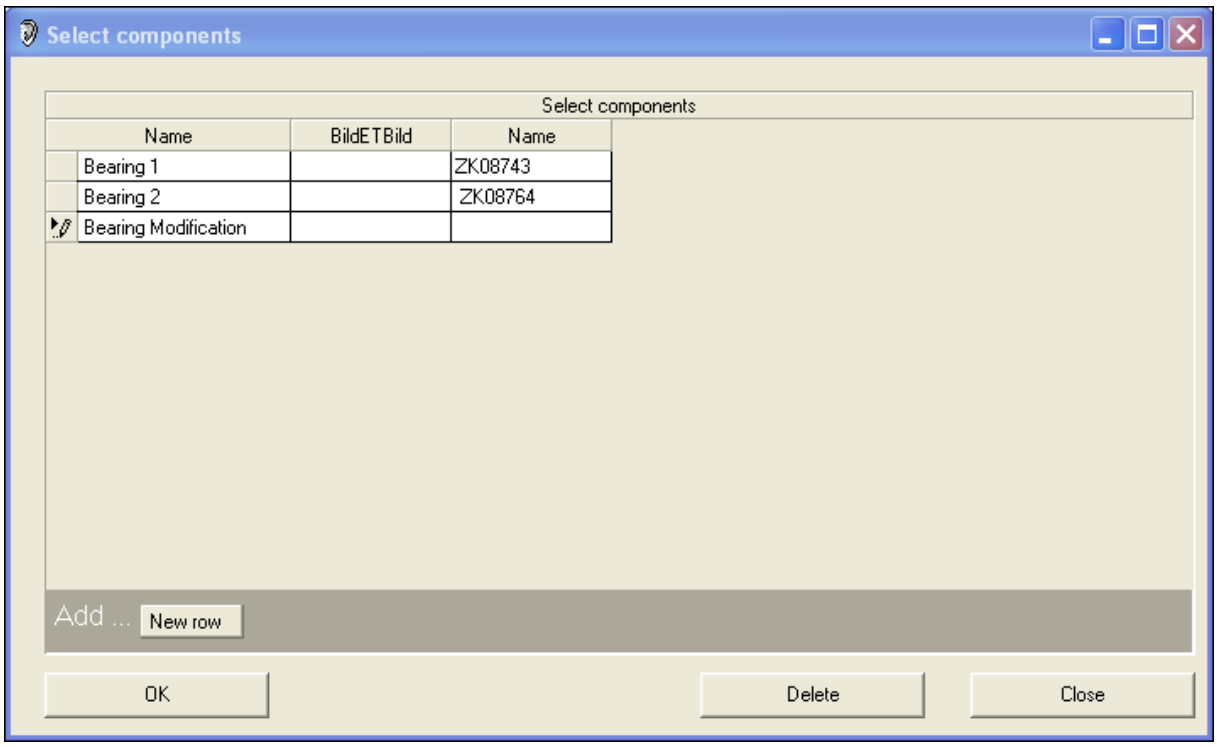

Fig. 75: Entering object components

In the dialog which then appears, you can enter the components.

To define a new component, hit the button "New row" and enter the desired data in the new row which then appears.

To delete a component, select the row to delete and hit the "Delete" button.

By closing the dialog with "OK", the currently selected components are associated with the measurement object selected. If you exit the dialog by pressing "Close", no association is created.

Now that the measurement object's type and components are defined, we can enter and assign descriptive information on the object.

The dialog for making entries for the object, which is the dialog called by the menu item "Tools – Measurement object", consists of two tables. The upper table contains the measurement objects and the lower one the

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components assigned to those objects. The current measurement object is always the last one to have been selected in the upper table. It can be distinguished by a black arrow in the first column.

14.4 How to create a new object

The "Measurement objects" dialog has a button appearing after the text "Add...", which reads "New object". Hitting this button adds a new row to the table, in which you can enter a new object.

14.5 How to assign a type and components to an object

The type can be selected from a pop-down list in the measurement object table. The list contains all types you previously defined.

To assign to the object one or more components, press the button "New assignment", and select the desired components from the dialog which then appears; then close the dialog using "OK". The components you select then appear in the lower table and are associated with the measurement object.

The other buttons, "Delete object" and "Copy object" can be used to delete an object or to copy an existing one, in which case the components with which it is associated are copied along with it.

Once you have made all the settings required you can exit the dialog.

14.6 How to assign Measurement objects to their measurements

Measurement objects can be assigned to data either before or after the measurement is carried out.

Before measurement, you can select the desired measurement object from the "Measurement object" combobox in the toolbar. Then if you start a measurement, the currently selected object is automatically applied.

Note:

> If you later scroll through the records of different measurements, this combobox will automatically indicate the measurement object involved.

If you accidentally select the wrong measurement object before measurement, or have forgotten to select an object, you can also make the assignment of the object to the data afterwards. To do this, select the

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menu item "Data – Overview...". In the table which then appears, you can at any time make or edit an entry in the "Measurement object" column in order to affect the association between data and objects.

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15 How to Use the Sensor Database

The sensor database offers the ability to organize your sensors, to save your scaling and adjustment constants, to monitor your calibration values etc.. The sensor database handles the entire administration of the sensors. If your sensors are entered in the database, you can configure their respective input channels at the click of a mouse, since all necessary information is saved in sensor database and all that is needed is to make a link between the input channel and the sensor database entry.

The sensor database has two dialogs:

1. the dialog for selecting sensors already present,
2. the dialog for defining new sensors or for editing existing sensors

In addition, the sensor database has a direct link to the calibrator database, which will be discussed later.

15.1 How to assign available sensors to input channels

When you connect a sensor to an input channel, all the input channel's settings parameters must be entered in the configuration dialog. The sensor database handles this task for you if the corresponding sensor is fully defined in the database.

In the input channel's configuration dialog, each row has a "Sensor" button. If you press it, the sensor database dialog opens.

The table in this dialog lists all sensors defined in the system. The sensors are identified by a name, type, serial number, etc.

You can "expand" the row by clicking on the "+" symbol in front of the row. Expanding shows all the respective sensor's outputs. This gives you the option of, for instance, administering tri-axial sensors or impedance probes with different numbers of outputs. Each output is numbered and can be assigned a name of your choice.

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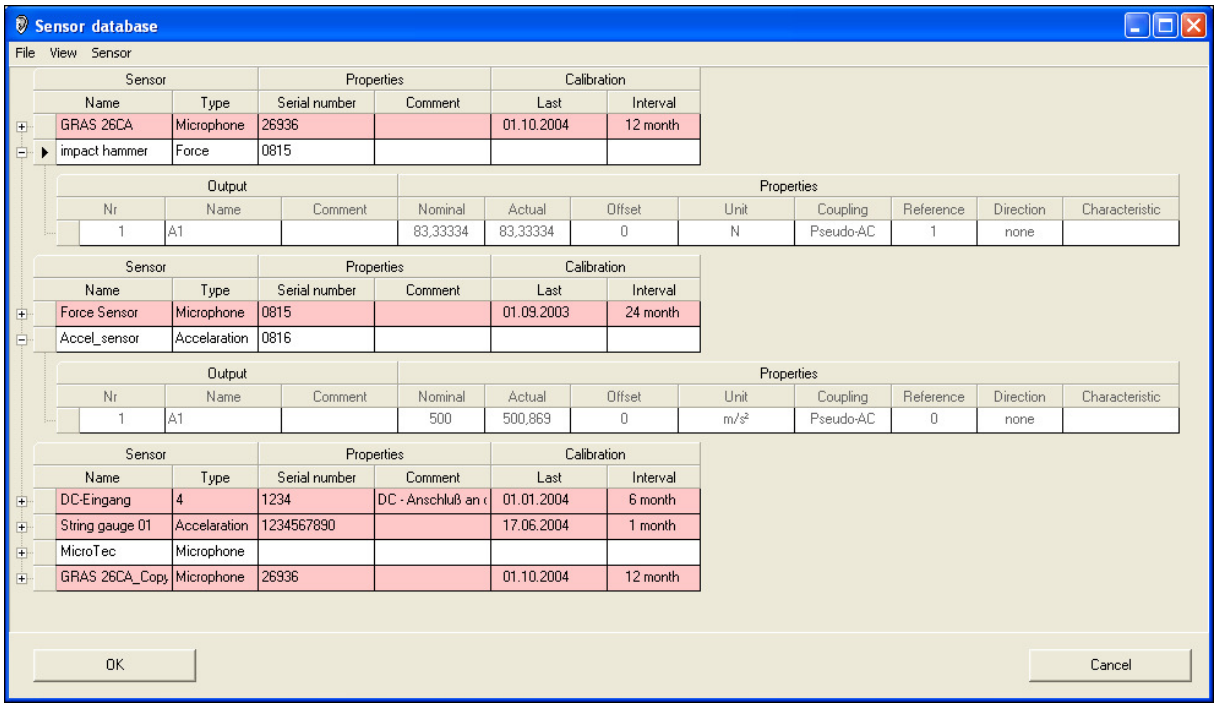
Sensor database
File View Sensor
Sensor
Properties
Calibration
Name Type Serial number Comment Last Interval
GRAS 26CA Microphone 26936 01.10.2004 12 month
impact hammer Force 0815
Output
Properties
Nr Name Comment Nominal Actual Offset Unit Coupling Reference Direction Characteristic
1 A1 83,33334 83,33334 0 N Pseudo-AC 1 none
Force Sensor Microphone 0815 01.09.2003 24 month
Accel_sensor Accelaration 0816
1 A1 500 500,869 0 m/s² Pseudo-AC 0 none
DC-Eingang 4 1234 DC - Anschluß an
String gauge 01 Accelaration 1234567890 17.06.2004 1 month
MicroTec Microphone
GRAS 26CA_Copy Microphone 26936 01.10.2004 12 month
OK
Cancel

Fig. 76: Sensor database selection dialog

By way of the "View" menu, you can pre-select which sensor type is to be displayed in the table. The pop-down menu contains all sensor types currently defined. When you select one of these sensor types, display in the table is limited to that type and the display of all other sensor types is blocked. You can return to displaying all types by selecting the menu item "All Sensors".

If you select the desired output from the table and exit the dialog with "OK", or simply double-click on the output in the table, the dialog is closed and the sensor output data are applied for the input channel.

The input channel is thus linked to the sensor database and many entries in the input channel's row in the configuration table are disabled. When there is a link, only the name, range and integration type can be selected.

To dissolve an existing link, use the button "Disconnect".

If you then call the sensor database selection dialog again, you will see additional controls.

In the selection dialog, additional sensors can be added, deleted or edited. To do this, right-click in the dialog to call a context menu from which you can select these options.

This dialog also indicates the time and date of the sensors' next calibrations. This calibration date is calculated on the basis of the last calibration and the calibrating interval specified by the user. If the sensor is due to be calibrated soon, its row in the table is shaded yellow, or red if

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it is overdue. However, the sensor is not disabled even if it's overdue for calibration.

15.2 How to define a new sensor in the sensor database

To be able to connect a new sensor to the measurement device and administer it using the sensor database, you must first define it in the sensor database.

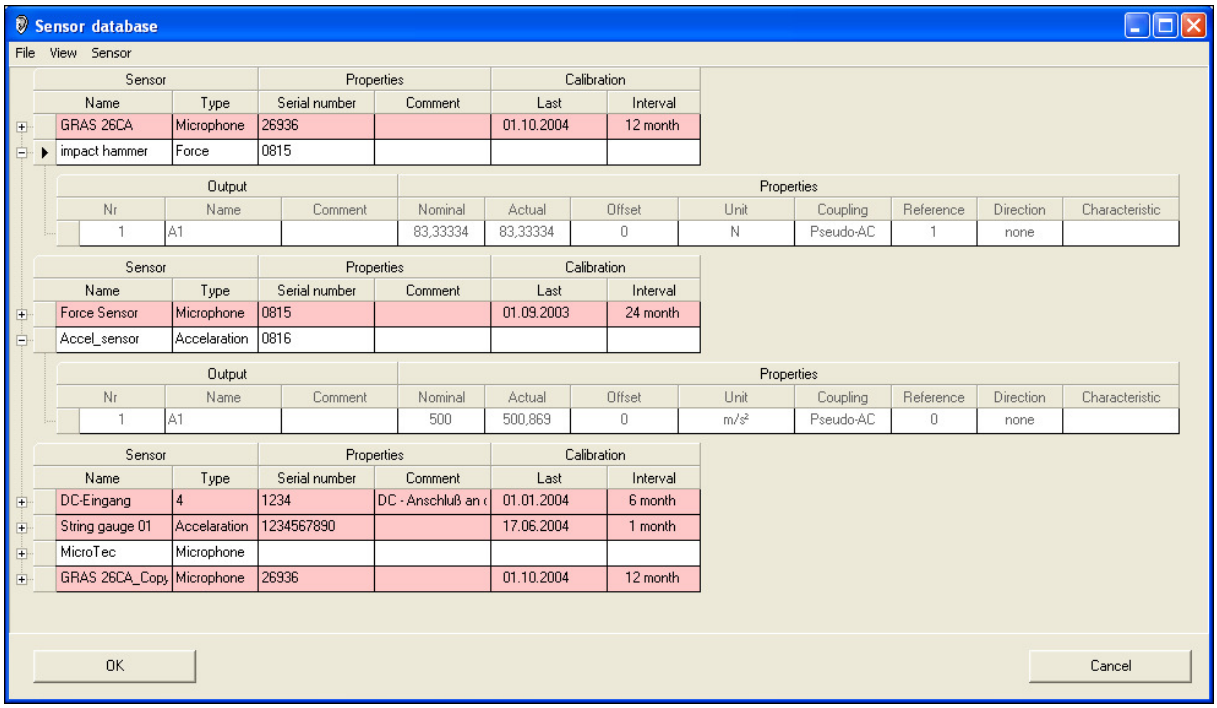
Sensor database
File View Sensor
Sensor
Properties
Calibration
Name Type Serial number Comment Last Interval
GRAS 26CA Microphone 26936 01.10.2004 12 month
impact hammer Force 0815
Output
Properties
Nr Name Comment Nominal Actual Offset Unit Coupling Reference Direction Characteristic
1 A1 83,33334 83,33334 0 N Pseudo-AC 1 none
Force Sensor Microphone 0815 01.09.2003 24 month
Accel_sensor Accelaration 0816
1 A1 500 500,869 0 m/s² Pseudo-AC 0 none
DC-Eingang 4 1234 DC - Anschluß an (01.01.2004 6 month
String gauge 01 Accelaration 1234567890 17.06.2004 1 month
MicroTec Microphone
GRAS 26CA_Copy Microphone 26936 01.10.2004 12 month
OK
Cancel

Fig. 77: Sensor database selection dialog

Definition of a sensor is performed in the sensor database selection dialog. This dialog is opened by clicking on the "sensor database" entry under the heading "Global" in the Project Explorer.

Right-click in the dialog and select the entry "New sensor". This calls the sensor database's configuration dialog.

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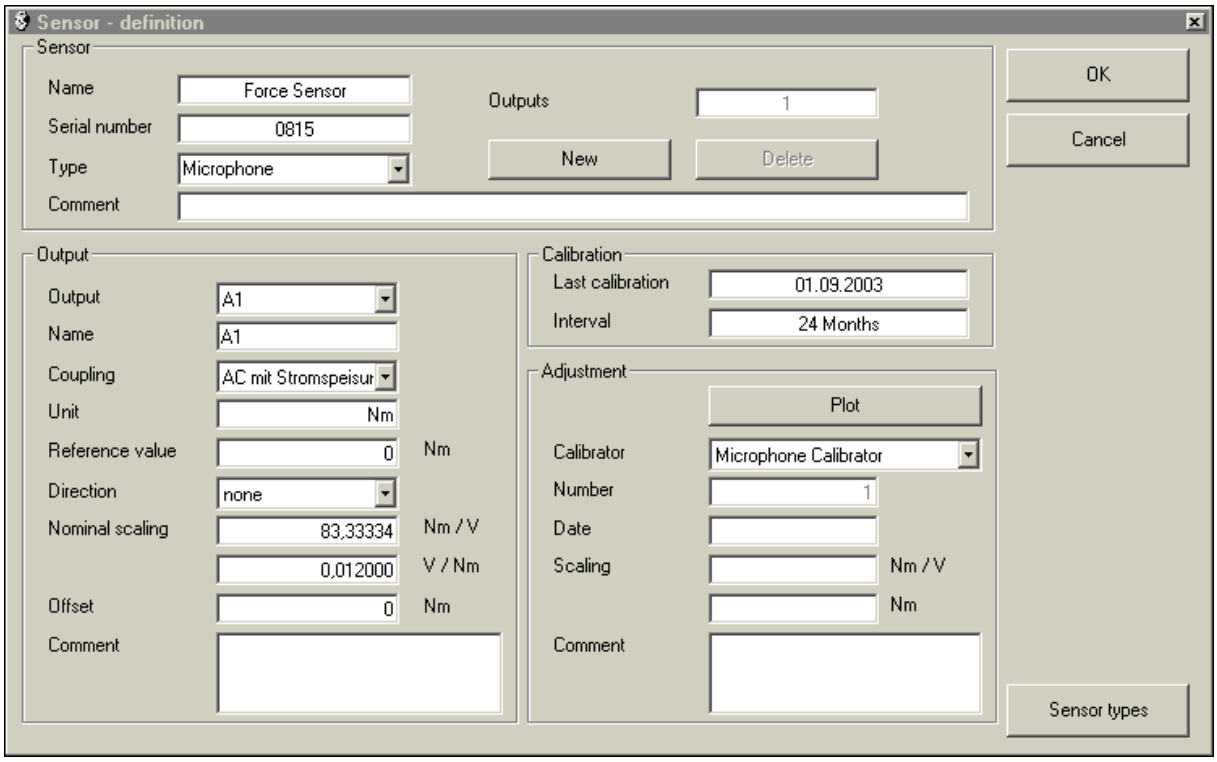

Fig. 78: Sensor database definitions dialog

In the sensor database's definitions dialog, you can make all settings for the configuration of the associated input channel, recognition of the sensor and administration of its calibration and adjustment data.

The sensors can be assigned any desired number of outputs. Thus it's possible to handle any sensors, whether accelerometers with one or three outputs (triaxial encoders), impedance probes with two outputs or even microphone arrays.

The dialog is subdivided into different areas:

1. **Sensor**
   Sensor specifications

2. **Output**
   Specifications on the sensor outputs

3. **Calibration**
   Specifications of the last calibration and the sensor's calibration interval. In imc WAVE, calibration refers to sensor calibration by an independent calibration laboratory.

4. **Adjustment**
   States the last adjustment performed on the sensor-to-device measurement chain. An adjustment in imc WAVE means the

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adjustment of the sensor-to-device measurement chain using a calibrator (e.g. Pistonfon or similar system).

The meanings of the individual dialog elements are as follows:

Sensor

- **Name**
  Name by which the sensor is identified in displays (e.g. in the configuration dialog for the input channels with appended name of sensor outputs, see below)

- **Serial number**
  Sensor serial number as a unique identifier

- **Type**
  Here you can choose a type from a list which you can extend. See also further below in this section for an explanation (cf. Sensor type)

- **Outputs**
  Here you can set the number of a sensor's outputs. By default, the number of outputs is 1. If your sensor has multiple outputs, you can add some to the configuration by pressing the button "New". Administering of and selection from among the multiple outputs you set are performed within the "Output" dialog.

- **Comment**
  Here you can enter a comment on the sensor.

Output

- **Output**
  Select here the current output on which the next few settings are to take effect. The amount outputs available for selection here is given by the setting for the number of outputs in the "Sensor" dialog.

- **Name**
  Name for the current output, by which it is identified, along with the sensor name, in the configuration dialog for the input channels.

- **Coupling**
  Select here the type for the coupling of the sensor to the input channel.

  The choices are:
  AC alternating current coupling

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DC	direct current coupling
PseudoAC	current fed AC-coupling

- **Unit**
  This is where to set the output's physical unit. Only set the basic unit, if possible in MKS – units, and imc WAVE will automatically compute any derivative units.

- **Reference value**
  This value is used in converting to dB, according to the formula

  $$L_x = 20\log_{10}(\frac{x}{x_0}),$$

  where x_0 is the reference value you supply.

  If you enter a reference value, imc WAVE will directly convert all quantities to dB. Otherwise, a channel's measured values are plotted on a linear scale.

- **Direction**
  Choose one of the Directions in the Combobox

- **Nom. scaling**
  The nominal scaling factor is what was determined for the sensor output at the last calibration by a calibration lab. It may be expressed either in terms of "(unit)/V" or as "V/unit". "(unit)" here represents the physical unit you selected for the sensor output.

- **Offset**
  You can add a constant offset to the sensor's output signal.

- **Comment**
  Here you can enter a comment on the sensor output.

Calibration

- **Last calibration**
  In this text box you can enter the date of the sensor's last calibration. Using this date and the calibration interval set in the next control, the next appointed calibration date is determined and a countdown arranged. If the sensor is due to be calibrated soon, its row in the table is shaded yellow, or red if it is overdue. However, the sensor is not disabled even if it's overdue for calibration.

- **Calibration interval**
  The next calibration appointment is calculated on the basis of the

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date of the last calibration performed and this specification (specify the interval in months).

Adjustment

- **Calibrator**
  A calibrator for the purpose of adjusting the respective output can be selected from a list here. This calibrator with its vibration value is then the basis for adjusting the sensor output. The list is then filled with the calibrator database's entries. The calibrator database is described in a later chapter of this manual.

- **Number**
  The adjustment's serial number. This number is generated and incremented automatically by the sensor database.

- **Date**
  Date of last adjustment

- **Scaling**
  This is the value determined at the last adjustment as the scaling factor in conjunction with the calibrator specified. The value is expressed either in "(unit)/V" or in "V/(unit)".

- **Comment**
  Here you can enter a comment on the calibration of the respective output.

- **"Plot" button**
  Pressing this button causes a curve window to open in which the sensor output's adjustment values are plotted over the adjustment dates. Thus you can observe how the adjustment values change over time, recognizing whether there is any trend or a random distribution.

Along with the input boxes and selection lists described above, the dialog also features certain other controls.

- **Sensor types**
  For administering sensor types

Sensor types

The sensor types were introduced into the sensor database in order to make classification of the sensors possible. This provides the ability to

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have only sensors of the desired type displayed in the selection dialog of the sensor database, so that the desired sensor can be located and assigned more quickly.

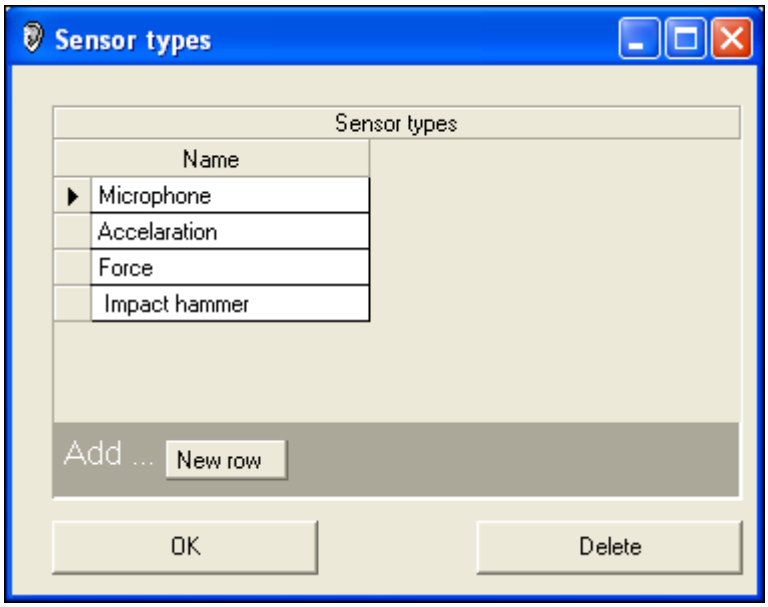

Fig. 79: Sensor type definition dialog

The sensor types are administered in their own table of the sensor database, allowing the user to add new types and to adapt the selection offered to his particular requirements.

To add a sensor type, push the "Sensor types" button in the sensor database's Definitions dialog.

The table of sensor types consists of a single-column table in which the sensor type names are indicated.

Next, press the "New row" button, which adds a new row to the table, in which you can enter the name of the new sensor type.

To delete a sensor type, select its row in the table and push the "Delete" button.

Once you have made all desired changes, close the dialog by pressing "OK".

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16 How to Use the Calibrator Database

The calibrator database can be used in conjunction with the sensor database and the adjustment of the entire measurement chain. For this purpose, the relevant calibrator parameters are stored in the calibrator database and are available for adjusting the measurement chain. For calibrators stored in the calibrator database, you need not enter their parameters at every new adjustment, but can load them straight from the calibrator database.

The calibrator database settings, then, are global; defined in common for all projects.

The calibrator database's definitions dialog is called by clicking on the entry "Calibrators" under the heading "Global".

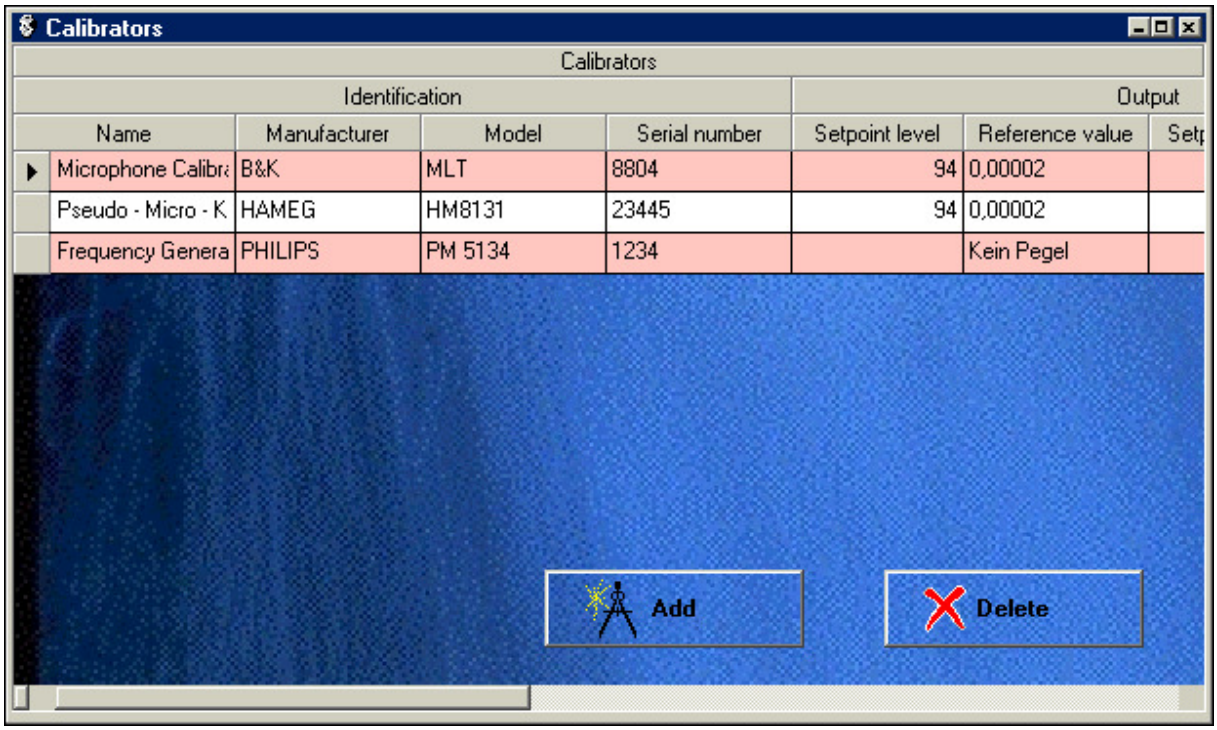

Fig. 80: Calibrator database definitions dialog

The calibrator database definitions dialog consists of a table in which all the calibrator parameters are presented.

To define a new calibrator, simply click on the button "New row". A new row is added to the table for the calibrator, to which you can now make entries. To delete a calibrator, select the desired calibrator in the table and press the "Delete" button.

The following parameters make up the definition of a calibrator:

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Identification
This is a composite of properties by which a calibrator is identified.

- **Name**
  The calibrator name is used for making a selection in the sensor database and for the adjustment.

- **Manufacturer**
  Name of calibrator's manufacturer

- **Model**
  Name of calibrator's model

- **Serial number**
  The calibrator's serial number

Output
Here, the calibrator's output property is defined.

- **Unit**
  This is where to set the output's physical unit. Only set the basic unit, if possible in MKS – units, and imc WAVE will automatically compute any derivative units. The unit for the calibrator's output signal is compared with that of the sensor output. Adjustment can only be performed by this calibrator for sensors having identical units to the output signal's. imc WAVE will not perform adjustment if the units don't match.

- **Reference value**
  This value is used in converting to dB, according to the formula

  $$L_x = 20\log_{10}(\frac{x}{x_0}),$$

  where x_0 is the reference value you supply.

- **Vibration value**
  Linear expected value of the output signal. This value can be looked up in the calibrator's calibration certificate.

- **Vibration level**
  This value can either be looked up in the calibrator's calibration certificate, or it is derived from the setpoint value using the reference value.

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Filter
The filter settings allow you to limit the relevant frequency range in which the adjustment is performed with the calibrator, in order to reduce interference signals and avoid adjustment failure.

- **Filter type**
  The available filter types are low-pass, high-pass, band-pass and band-stop. Depending on the filter type selected, values for the following parameters may need to be entered.

Low-pass:	Frequency1: cutoff frequency Frequency2= not used
High-pass:	Frequency1: cutoff frequency Frequency2= not used
Band-pass:	Frequency1: lower cutoff frequency pass range Frequency2: upper cutoff frequency pass range
Band-stop:	Frequency1: lower cutoff frequency stop band Frequency2: upper cutoff frequency stop band

- **Frequency1**
  Definition of the cutoff frequencies (see above)

- **Frequency2**
  Definition of the cutoff frequencies (see above)

Calibration
Under this heading, all information needed for performing and timing the calibration of the calibrator are stored. Using the other parameters, the system does a countdown to the next calibration appointment. This dialog also indicates the time and date of the sensors' next calibrations. This calibration date is calculated on the basis of the last calibration and the calibrating interval specified by the user. If the sensor is due to be calibrated soon, its row in the table is shaded yellow, or red if it is overdue. However, the sensor is not disabled even if it's overdue for calibration.

- **Last Calibration**
  Date that the calibrator was last calibrated by a calibration laboratory

- **Calibration interval**
  Time interval since the last calibration at which the next calibration must take place

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Description
Additional information on the calibrator

- **Frequency**
  Calibrator output frequency

- **Comment**
  For entering a special comment on the calibrator, e.g. tips on conducting a calibration, etc.

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17 How to Adjust the Entire Measurement Chain

In acoustic engineering, it is customary to perform an adjustment of the entire measurement chain before taking a measurement. imc WAVE supports you in performing such an adjustment with a special dialog for this particular task, which can both make use of the sensor and calibrator databases and enable manual adjustment. In a manual adjustment, the calibrator's vibration value can be set in the Adjustment dialog.

Once an adjustment procedure has been completed, the adjustment value obtained becomes the new scaling factor for the channel and is a particular property of the respective project.

There are two different ways of performing the adjustment:

- **Manual adjustment**
  The adjustment is performed by manually initiating the measurements needed for computing the adjustment factors.

- **Automatic adjustment**
  With automatic adjustment, the sequence of measurements has a specified order. Between individual measurements necessary for determining the adjustment values, delay times can be defined. The measurement begins in response to a freely configurable threshold value trigger.
  This method of adjustment is recommended for cases of large numbers of sensors working in a multi-channel system, and also where there are great distances between the individual sensors.

Both methods will be described in greater detail in the sections below.

17.1 Manual adjustment

The Adjustment dialog can be called for each input channel individually. To do this, select the channel desired in the configuration dialog and right-click the mouse over the beginning of its row in the table. From the context menu which then appears, select the item "Adjustment".

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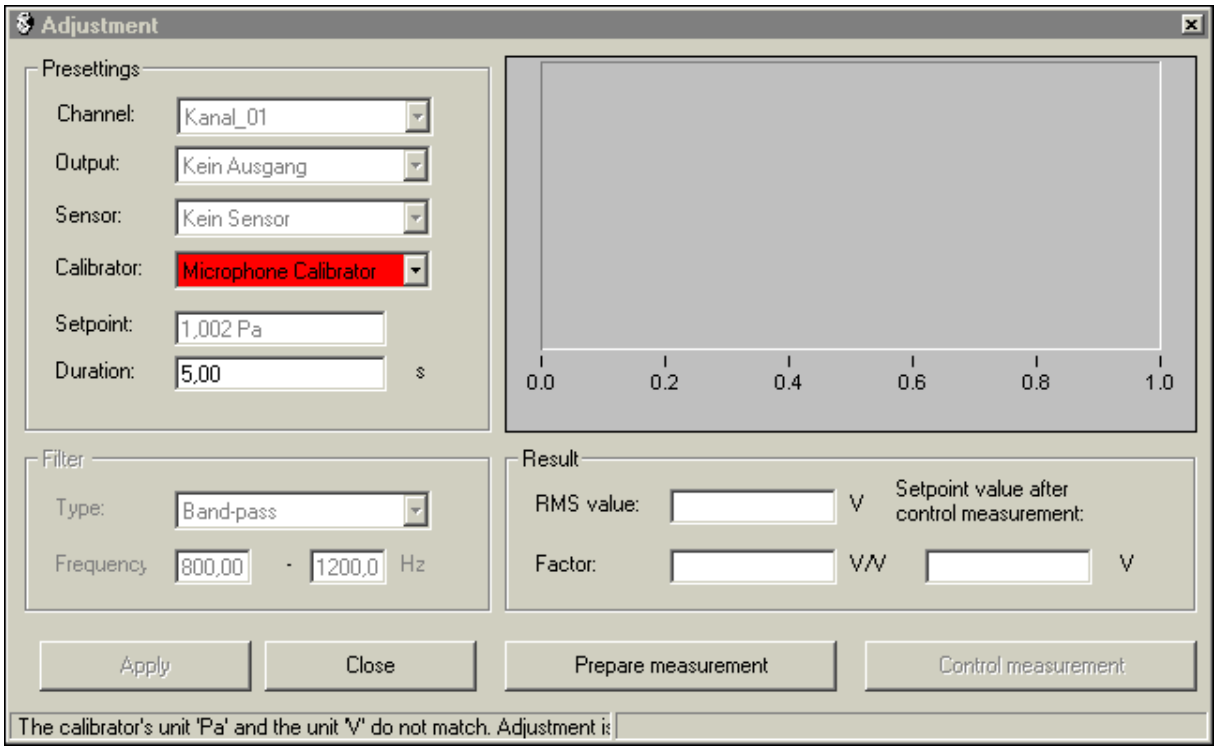

Fig. 81: Adjustment of the entire measurement chain

17.1.1 How to configure manual adjustment

The Adjustment dialog then presents the information on the desired input channel adjustment:

Presettings

- **Channel**
  Name of input channel to which the sensor to be adjusted is connected.

- **Output**
  Selection of the output for the sensor selected above, if the input channel is registered in the sensor database, otherwise "No output".

- **Sensor**
  Selection of a sensor from the sensor database or "No sensor" if the input channel is not registered in the sensor database.

- **Calibrator**
  Select here the calibrator with which adjustment is to be performed. That can be done automatically by the sensor database or manually by the user if the input channel is not registered in the sensor database. You can also select the entry "Unknown calibrator". This

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allows you to directly specify the vibration value for the calibration.

- **Setpoint value**
  The calibrator's output quantity, either linear or as a level, depending on the setting

- **Duration**
  Time allotted for data acquisition. The RMS-value over this time is calculated.

Filter
The calibrator database sets the filter for suppressing interference in the measurement signal, or you can do so manually:

- **Filter type**
  The available filter types are low-pass, high-pass, band-pass and band-stop. Depending on the filter type selected, values for the following parameters may need to be entered.

Low-pass:	Frequency1: cutoff frequency Frequency2= not used
High-pass:	Frequency1: cutoff frequency Frequency2= not used
Band-pass:	Frequency1: lower cutoff frequency pass range Frequency2: upper cutoff frequency pass range
Band-stop:	Frequency1: lower cutoff frequency stop band Frequency2: upper cutoff frequency stop band

- **Frequency1**
  Definition of the cutoff frequencies (see above)

- **Frequency2**
  Definition of the cutoff frequencies (see above)

Result
In this box, the results of the adjustment and of the control measurement are displayed.
The adjustment values are calculated by performing an initial measurement, for which the RMS-value of the input signal is calculated without a scaling factor. From the ratio of the input signal's RMS-value to the calibrator's vibration value, the adjustment factor or scaling value is determined.
Next, this adjustment value is entered as the input channel's scaling value and a control measurement is carried out. This control measurement

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measures the calibrator's vibration value with the adjustment's scaling factor determined from the initial measurement, and displays the result.

The following quantities are displayed:

- **RMS value**
  The RMS value calculated during the adjustment

- **Factor**
  Adjustment factor derived from the vibration value and the RMS value calculated

- **Setpoint value after control measurement**
  Vibration value determined after the control measurement with the adjustment factor and the calibrator selected.

17.2 How to perform adjustment

Once you have made the entries required in the dialog, or the sensor and calibrator databases have filled in the appropriate entries, you can begin the adjustment by pressing the button "Prepare measurement" and afterwards "Start measurement". Make sure that your calibrator is connected to the sensors and activated according to the manufacturer's instructions. The measurement is carried out fully automatically. The results are then displayed in their respective boxes.

If you wish to carry out an additional control measurement after adjustment, press the "Control measurement" button. The control measurement is carried out fully automatically and the results are shown in the corresponding box.

If you close the dialog by pressing "OK", the results of the adjustment are applied. If you exit the dialog using the "Cancel" button, the results are discarded.

17.3 Automatic adjustment method

Automatic adjustment provides added convenience in performing adjustment of multi-channel systems, or of systems with widely separated sensors. A typical case for performing automatic adjustment is sound power measurement. Such measurements generally employ a large number of microphones which, depending on the size of the measurement object, can be distantly spaced.

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To have adjustment performed automatically, open the associated dialog by double-clicking on the Project Explorer entry “Automatic adjustment”.

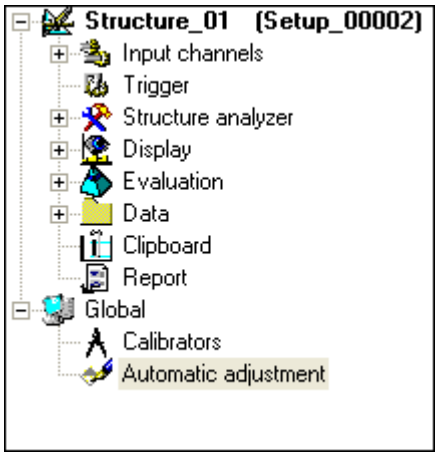

Fig. 82: Starting automatic adjustment

The automatic adjustment cannot be used for bridge channels.

17.3.1 How to configure the automatic adjustment

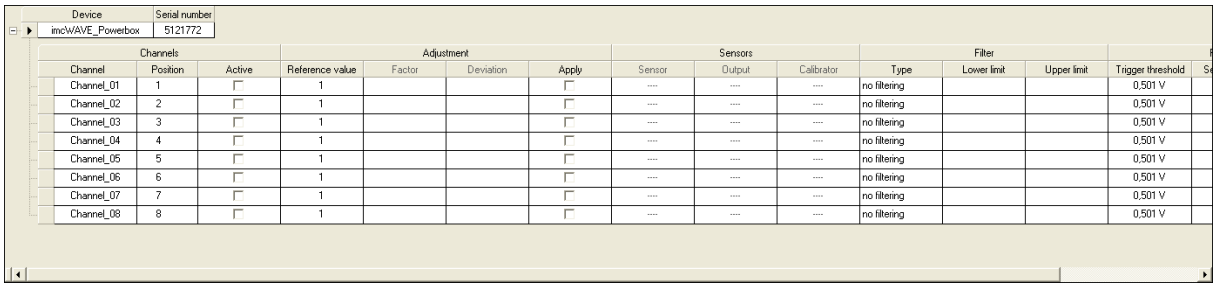

Fig. 83: Configuration dialog for making channel-by-channel settings

Before automatic adjustment is performed, the individual channels to be adjustment must be configured to suit the sensors and calibrators to which they are respectively connected.

The automatic adjustment’s configuration dialog contains a variety of controls which must be set before the adjustment can be carried out.

Channels

Configuration of the adjustment procedure and selection of the results to be applied

- **Name**
  Display of the channel name

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- **Position**
  Sets the order of measurements for determining the adjustment factors; the number representing the position sets at which position (in the order) the current channel is adjusted.

- **Active**
  Activates the channel for automatic adjustment

Adjustment

Displays the specifications and the computed factors, as well as their deviations and capability of the adjustment result to be applied manually

- **Reference value**
  The sensor's nominal factor

- **Factor**
  The factor computed for the adjustment

- **Deviation**
  Proportional discrepancy between the reference value and the factor

- **Apply**
  Selecting the checkbox for this option lets you apply the adjustment results. If the adjustments is flawed, it is possible in this way to suppress overwriting of the adjustment values with flawed values.

Sensors

If the channel is linked to an entry in the sensor database, the sensor database settings are displayed here.

- **Sensor**
  The sensor's name

- **Output**
  Designation of the output; only relevant for multi-channel sensors, e.g. impedance probes, triaxial sensors

- **Calibrator**
  Designation of the calibrator assigned to the sensor

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Filter

Definition of a digital filters for the measured data used for the adjustment. This filter can be used to suppress disturbances.

- **Type**
  Selection of the filter type

  Available selections:
  - No filtering
  - Low-pass
  - High-pass
  - Band-pass

- **Lower limit**
  Definition of the lower cutoff frequency for the band-pass or the range limits for high-pass or low-pass

- **Upper limit**
  Definition of the upper cutoff frequency for the band-pass or the range limits for high-pass or low-pass

Presettings

Definition of external settings which affect the adjustment procedure:

- **Trigger threshold**
  Definition of the trigger threshold, at which the measurement is started,

- **Setpoint value**
  Definition of the value to which to tune the measurement,

- **Control**
  Control display for the adjustment.

After configuring the measurement quantities for the adjustment, the adjustment procedure itself must be defined. For this purpose, the lower portion of the dialog contains three more input boxes referring to all channels.

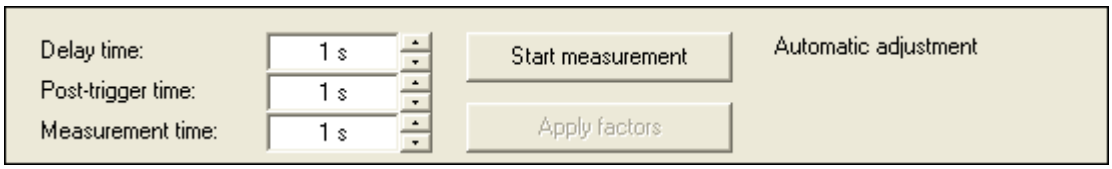

Fig. 84: Configuration dialog for universal channel settings

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The adjustment procedure is based on stages of certain time durations:

- **Delay time**
  This setting defines the maximum time which will be needed to move the calibrator from one sensor to another and to hook it up.

- **Post-trigger time**
  This "warm-up time" is designed to cover the time needed for all signal transients to subside.

- **Measurement time**
  This interval ultimately determines the duration of data acquisition. The data measured are then used to compute the adjustment factor.

17.3.2 How to be perform automatic adjustment

For automatic adjustment to be performed, all sensors must be connected with the measurement device. Once configuration of the measurement is complete, automatic adjustment can be started by clicking on the button "Start measurement" in the lower portion of the dialog.

You must next connect the calibrator with the sensor connected at the channel to which the position 1 was assigned. The measurement starts after the trigger threshold has been crossed and later stops automatically. The calibration data are computed automatically and entered into the table.

Then you can proceed to the next sensor and repeat the procedure.

Once all sensor have taken their measurements, you can decide for which sensors you wish to apply the data. To do this, click the option checkbox "Apply" in the field "Adjustment". All adjustment factors marked for applying are then entered into the table of input channels as factors when the button "Apply factors" is clicked.

This completes the automatic adjustment and lets you proceed with the measurement process.

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18 imc WAVE Data Structuring Capabilities

imc WAVE offers a variety of structuring elements for organizing, administering and retrieving captured data.

This chapter presents a short survey of the options and their respective advantages and drawbacks. The introduction presents merely one suggestion for how to administer the data, but there are many other possibilities. The individual elements are each described in their own chapters.

In data structuring, there is a basic distinction between local and global elements.

18.1 Local structuring elements

The local elements are properties of particular projects and are not available to other projects.

The following local elements exist:

1. Projects
2. Groups
3. Measurements

18.1.1 The structuring role of projects

A project is an element encompassing settings, acquired measurement data and display options. A project supports a single analyzer which is selected when the project is created from a pool of available analyzers. The project administers the various settings for you, which can be changed within the project, and always attributes data to the settings used when acquiring them.

The project is given a name when it is created, by which it can be identified in the records.

18.1.2 The structuring role of groups

Group elements can be created locally within a project-element. If you create a group element, the name you designate for it appears in the project explorer under the heading "Data".

It is now possible to move measurements within the group, or to combine multiple measurements under a common designation.

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The sound power analyzer needs data to be structured in groups in order to be able to compute the production statistics. In this case, the different measurements are merged into the group and only the mean value is used in subsequent processing.

Groups cannot be related hierarchically and are one-dimensional.

18.1.3 The structuring role of measurements

The element "measurement" is composed of a number of processed and stored data sets. Signal data and the quantities derived from them by the analyzer are stored under the measurement-element. The "measurement"-level elements appear in the Project Explorer under the heading "Data". There is a variety of ways to identify these elements in the Project Explorer; they can take proper names, or be titled according to their date, or have a serial number.

18.2 Global structuring elements

In contrast to local elements, the global ones are available for inclusion in any project. If such an element is changed, it affects every project concerned.

The following global elements exist:

1. Measurement object types
2. Components
3. Measurement objects

In contrast to local elements, these elements have a purely descriptive function with regard to the measurement objects.

18.2.1 The structuring role of measurement object types

The type is a global property shared by a number of different measurement objects.

18.2.2 The structuring role of components

Different measurement objects each have their own complement of components.

18.2.3 The structuring role of measurement objects

A measurement object is the article on which a test is performed. Such an object belongs to a "type" and consists of a number of "components".

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18.3 A data structure example

After having dealt with so much theory, we can now investigate an example of structuring elements in a specific measurement application.

18.3.1 The example application

We will use imc WAVE to perform acceptance and development tests of electric motors. Each month, we receive about 20 - 30 different motors taken from serial production and must additionally test prototypes for development purposes.

The measurement objects are to be subjected to sound power and FFT analysis. For the sound power measurements, accompanying production statistics are to be compiled.

These serial motor types exist:

1. KUM
2. KUX
3. KZU

The types are distinguished by their components, (line filter, leads with terminals, housing model).

Different serial motors of the same type are distinct in the diameters of their output shafts:

1. KUM21
   Shaft diameter 21
   Measurement object serial numbers 01, 02, 03, 04, 05, 06, 07, 08, 09, 10

1. KUM 23
   Shaft diameter 23
   Measurement object serial numbers 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

2. KUM27
   Shaft diameter 27
   Measurement object serial numbers 21, 22, 23, 24, 25, 26, 27

3. KUM34
   Shaft diameter 34
   Measurement object serial numbers 31, 32, 33, 34, 35, 36, 37, 38, 39

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4. KUX22
   Shaft diameter 22
   Measurement object serial numbers 41, 42, 43

5. KUX34
   Shaft diameter 34
   Measurement object serial numbers 51, 52, 53, 54, 55, 56, 57, 58, 59, 60
   Prototype E101, E102, E103

6. KZU11
   Shaft diameter 11
   Measurement object serial numbers 61, 62, 63, 64, 65

7. KZU13
   Shaft diameter 13
   Measurement object serial numbers 71, 72, 73, 74, 75, 76, 77, 78

All measurement objects are to undergo sound power testing and the prototypes E101, E102, E103 additionally undergo FFT analysis.

18.3.2 Structuring the application

We first deconstruct the application into global and local structuring elements:

Global elements

Measurement object types:
- KUM
- KUX
- KZU

Components:
- Line filter (specify desired types)
- Leads with terminals (specify desired types)
- Housing model (specify desired types)

Measurement objects:
- Measurement objects are entered according to the serial numbers stated above. Also the prototypes.

Thus, the global objects are all defined and can later be assigned to the appropriate "measurement"-elements. Till now, we have only set up descriptive elements.

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Local elements

For organization and backup purposes, we next create sub-folders named after the measurement object types in the folder in which we intend to store data. The folders can be created using either imc WAVE or the Windows Explorer. the sub-folder names are then

KUM,
KUX,
KZU.

Within the respective sub-folders, we set up imc WAVE projects for the various shaft diameters.

KUM
    KUM21_SHL
    KUM23_SHL
    KUM27_SHL
    KUM34_SHL
KUX
    KUX22_SHL
    KUX34_SHL
KZU
    KZU11_SHL
    KZU13_SHL.

We assign the sound power analyzer to these projects.

In the KUX folder, we also set up a project named KUX34_FFT, to which we assign the FFT analyzer.

Now all projects have been set up and we can configure the individual projects according to our requirements. The way to do this has been described in previous chapters of this manual.

Now we can get started taking measurements. We select one of the Measurement objects and load the appropriate project.

Before measurement starts, we load the entry corresponding to the desired measurement object by making a selection from the "measurement object" list box in the toolbar. Upon completion of the measurement, the measured data appear in the Project Explorer, denoted by serial numbers, dates or (user-supplied) names, under the heading "Data". These data are automatically associated with the correct measurement object in the measurement object database. You can repeat

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this process with the result that new measurement data sets will appear in the Project Explorer, each under its own name.

The individual data sets from the sound power measurements are grouped under a single measurement. Within this structure, they are administered and displayed.

We can now join the various repeat measurement runs to a group. To do this, set up a group in the Project Explorer under the heading "Data" and move the data sets into this group.

The data sets belonging to the group can now be included into a report as a measurement series or can be used to compile production statistics. For the Sound Power Analyzer production statistics, the individual measurement runs are averaged and the mean value is used in calculating the statistics as per ISO 4871. This allows you to place data sets into or remove them from groups easily, in order to be able to observe the influence of particular data sets on the production statistics.

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19 How to enable analyzers

Imc WAVE can come with various numbers of analyzers with a broad range of applications. Since not every user needs all of the analyzers, they are offered separately and accordingly enabled for the respective system purchased. Only an analyzer's full functional scope is enabled and not any subdivided portions of one.

Which analyzers are enabled depends on the particular measurement device. If you wish to use more than one measurement device, all measurement devices must be enabled for any analyzer used.

When setting up a new project, a list of all the analyzers enabled for the devices is displayed as soon as the devices are selected. The analyzer for the project to set up can only be selected from the list of these analyzers.

To activate a device for an analyzer, select the menu item "Tools – Activating".

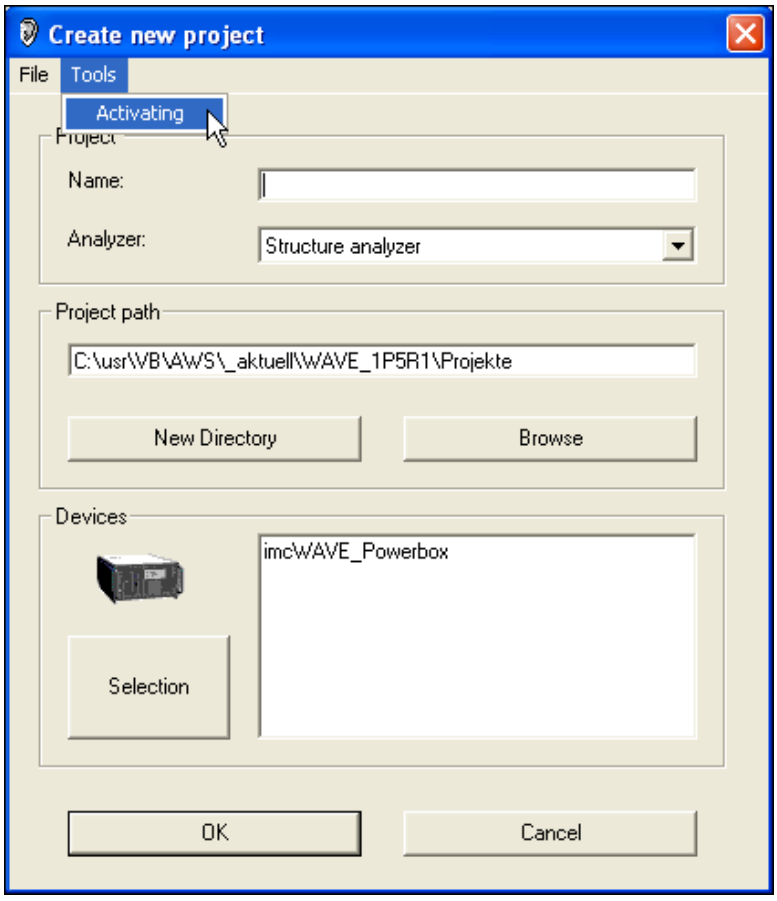

Fig. 85: Creating a new project while enabling an analyzer

The dialog shown below appears.

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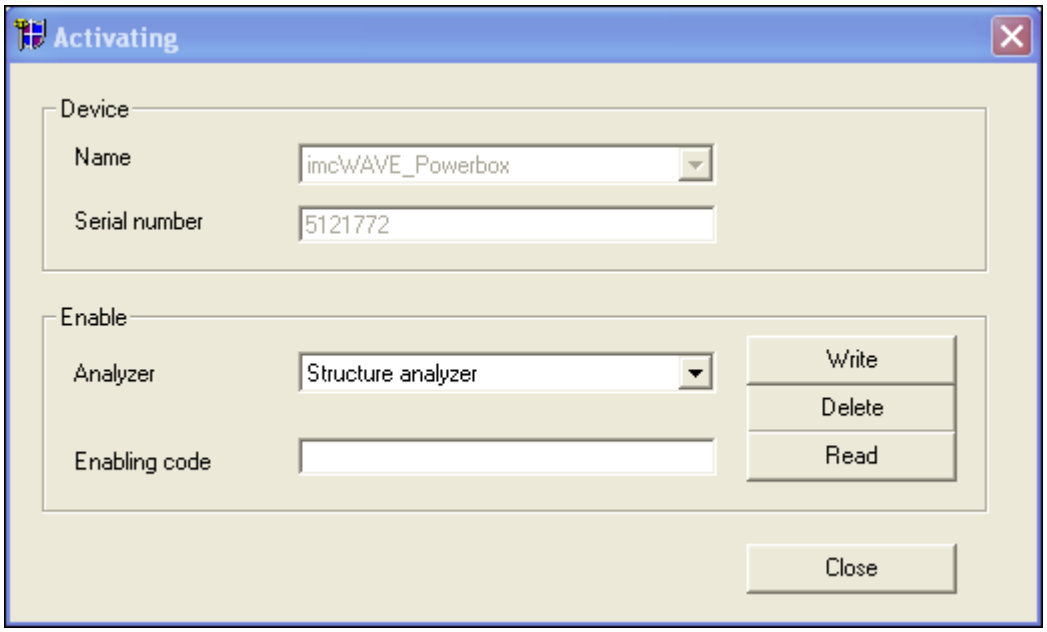

Fig. 86: Dialog for enabling analyzers

Using this dialog, you can now activate the device indicated. To do this select the desired device from the list and select the analyzer which you wish to enable for the device using the pop-down list.

To enable an analyzer, the appropriate enabling code is needed. This code can be obtained from your local distributor. If you have any questions, please contact your distributor.

If you already have the necessary enabling code, enter it in the “Enabling code” input box and click on the button “Write”. This causes the enabling code to be written to the device. Then the analyzer selected is available for your use.

If you aren’t sure which analyzers are enabled in your device, click on the button “Read”. A list indicating all analyzers enabled for your device is displayed. Note that this list only pertains to the current device.

Additionally, you have the option of deleting any individual analyzer enabled for your currently device. To do this, select the device and the analyzer to be deleted and click on the button “Delete”. This deletes the enabling code from your device and the respective analyzer is no longer available for measurements.

Whenever a new project is created, the system checks which analyzers are enabled, since the list of analyzers only indicates those which are enabled. Further, upon preparation of measurements, the system verifies whether the particular analyzer is even enabled for the current device. If either of these conditions is not met, no measurement is carried out.

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If you have any questions or problems pertaining to the enabling of analyzers, please contact the distributor representing your geographical area, who will be happy to assist you.

You can also obtain information at any time from our homepage at www.imc-wave.de, or you can directly contact us at wave@imc-berlin.de.

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20 How to start a measurement

After creating a project, selecting and configuring the display, and configuring the analyzers (see below), measurement can be prepared and started.

Imc WAVE essentially distinguishes between two measurement modes:

1. **Measurement with an analyzer**
   Measurement with an analyzer is the default case for which imc WAVE is actually designed. Here, the capability is provided to display and store all output channels previously computed in the analyzer.

2. **Measurement in the Quick View mode, without analyzer**
   In contrast to measurement with an analyzer, there is no display of an analyzer's output data in Quick View mode. In this mode, no such data are computed. For display purposes, only the physical input data are available. These data are not saved directly by imc WAVE. This mode is designed for obtaining a quick scan of time data returned by the sensors. See the description of this mode below to learn about further limitations.

20.1 Measurement with the analyzer

The analyzer, which is the heart of imc WAVE, computes the desired output channel signals from the data provided by the input channels. These channels can then be displayed and stored along with the input channels.

To activate the output channels, select the analyzer's configuration dialog and make the appropriate settings.

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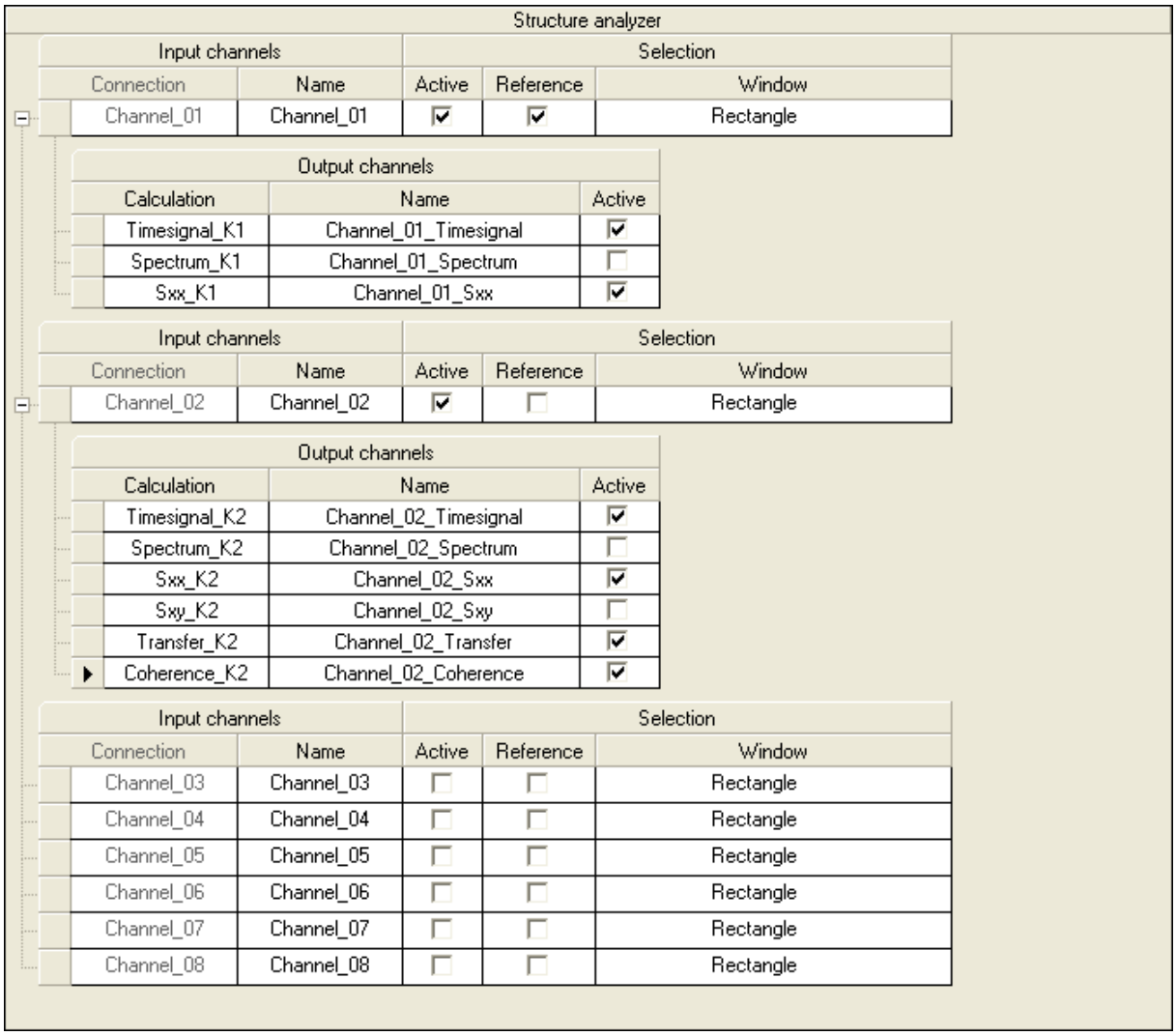

Fig. 87: Example: The Structure Analyzer's configuration dialog

In this measurement mode, full access to the output channels is provided. Furthermore, any settings you may have made in the trigger dialog are supported and applied to the measurement.

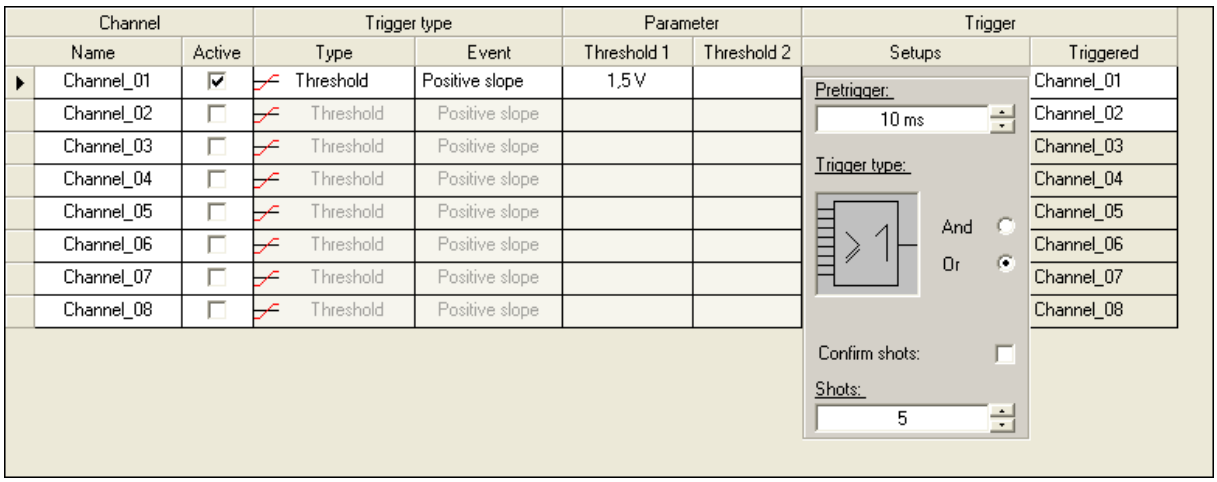

Fig. 88: Example: Trigger settings

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Once you have made all settings, the configuration must be transferred to the measurement device; to do this use the toolbar button or the item "Prepare" in the "Hardware" menu. A measurement experiment of the respective type is created and transferred to the measurement device. Once creation and transfer of the configuration are complete, it is possible to start the measurement by means of the button .

While the measurement is running, the red LED in the imc WAVE toolbar flashes.

20.2 Quick View measurements

The Quick View measurement mode enables you to get a quick overview of all active channels of the connected measurement devices, without complications.

For instance, if you have connected all sensors with your measurement device, have configured the desired channels in the Input Channels dialog, have activated the analyzer and now wish to check whether all sensors are returning correct measurement results, using the Quick View measurement mode is an easy way.

The Quick View mode is called either by clicking on the button or by selecting the item "Quick View" in the "Hardware" menu. After activating the Quick View mode, the following settings in the associated dialogs are ignored:

1. Analyzer
   The output channel settings and activations are disregarded.

2. Trigger dialog
   The trigger dialog settings are entirely disregarded.

3. Saving of data
   Saving of measured data, for example, automatic storage of the data at the end of the measurement is deactivated.

The Quick View mode has its own configuration dialog offering limited options for making settings for the measurements. In order to have the configuration dialog displayed, click on the button or select the item "Configuration Quick View" in the menu "Hardware".

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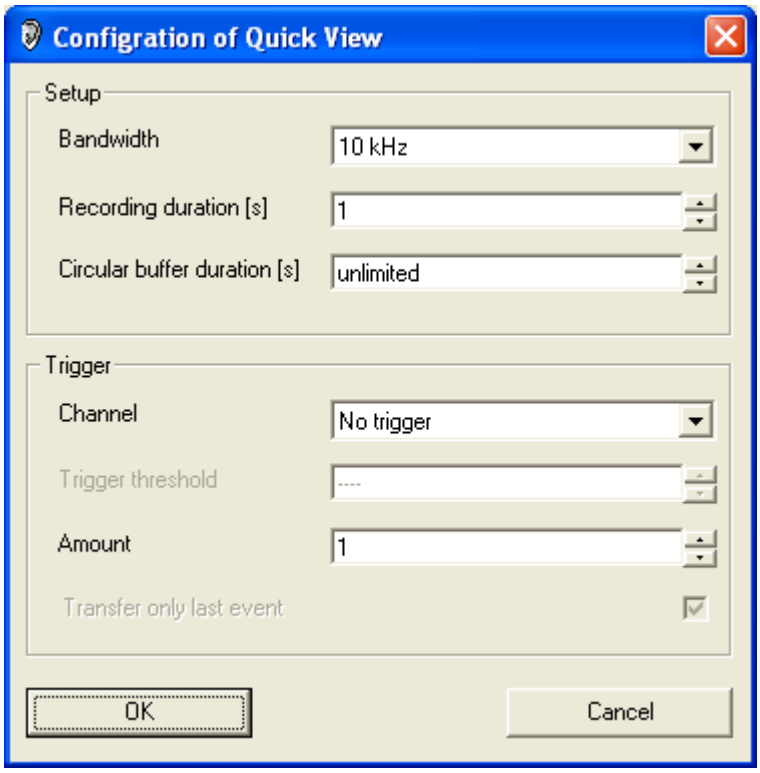

Fig. 89: Quick View Configuration dialog

The configuration dialog offers the ability to make settings for the data acquisition and the trigger.

Settings

- **Bandwidth**
  Here, you can set the desired bandwidth for the data acquisition. Bandwidths of 1 – 20 kHz are available.

- **Recording duration**
  Here, enter the desired duration for recording of a signal, stated in seconds. Each measurement or each trigger releasing event is then recorded for the time specified.

- **Circular buffer duration**
  Here you can enter a time interval for the circular buffer memory, or to deactivate the buffer memory by specifying unlimited duration.

Trigger

The only triggering supported is unlinked threshold value triggering on one activated input channel.

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- **Channel**
  Selects the channel to be used for threshold value triggering.

- **Trigger threshold**
  Enter the desired trigger threshold for the input selected in the control "Channel" above.

- **Amount**
  Here, the desired amount of trigger events is specified. The setting "1" is the default setting, where only one measurement (trigger event) occurs and data acquisition immediately stops afterward.

- **Transfer only last event**
  For setups involving more than one trigger, this option allows you to omit display of measurements from previous triggered events. To activate it, set a check in this control's box. After each new trigged event, the result of the previous triggered event is deleted and only the data from the new triggered event is displayed.
  Whenever this option is not active (when the checkbox is empty), all data from the triggered event are transferred from the measurement device to the PC, and an unlimited amount of triggered events can cause an overflow.
  Alongside this option, the curve window also offers the possibility of viewing only the last event (to do this, select the item „Window Configuration – Events" in the curve window menu). The difference is that this setting only affects the display in the curve window: only the last event is shown, but the transfer of all events from the measurement device to the PC is not cancelled.

After completing configuration of the Quick View measurement mode, we can exit the dialog. Then, as with the analyzer, measurement is prepared by clicking on the toolbar button and started using the button .

It is then possible to display the measured data (time plots of the physical input signals) in the curve window as accustomed, and to combine the displays in screen views.

Notes

- The option to save measurements is not provided in Quick View mode. If you wish to save data, simply transfer the data from the curve window to imc FAMOS and save the data from there directly.

- Measurements carried out in Quick View mode are not even saved under Data in the Project Explorer.

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The configurations made for the Quick View mode are not administered or saved as a setup. This means that any new settings made always overwrite the old ones. In contrast to settings made for the analyzers, any old settings cannot be restored.

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21 The Structure Analyzer

The Structure Analyzer in imc WAVE was specially designed for performing structural analysis. It supports you in acquiring data and computing derived quantities with a wide scope of functions, with which you are able to evaluate the results directly during the measurement. The computations apply Fourier transformation. Explanations on Fourier transformations are provided in this chapter.

The Structure Analyzer settings are particular properties of a specific project.

21.1 The background of FFT

The Fourier Transformation is named after the famous French mathematician Jean Baptiste Joseph Fourier (1768 - 1830).

Fig. 90: Jean Baptiste Joseph Fourier (1768 – 1830)

In the early 19th century, Fourier investigated heat conduction and in his seminal work "La theorie analytique de la chaleur (1822)" showed that this process could be modeled by trigonometric series and integrals of one variable. This meant that an unsteady function could be represented by a sum of sine functions of various amplitudes.

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Defining f(t) as the course of a physical process over time and H(w) as the amplitudes resulting from the substitution with trigonometric functions, both representations describe the same physical process.

Transforming from one representation to the other is accomplished for periodic signals using the Fourier series development

$$f(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos(n\omega t) + b_n \sin(n\omega t)$$

where

$$a_n = \frac{2}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} f(\tau) \cos(n\omega\tau) d\tau$$

$$b_n = \frac{2}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} f(\tau) \sin(n\omega\tau) d\tau$$

and for aperiodic signals using the Fourier transformation

$$F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt$$

$$f(t) = \int_{-\infty}^{\infty} F(\omega) e^{j\omega t} dt$$

Letting the variable t stand for time and f(t) thus for the function over time, we obtain $\omega = 2\pi f$ for the angular frequency and $F(\omega)$ for the complex frequency spectrum.

The Fourier transformation is a well-studied field on which there are a large number of books presenting proofs, conditions for existence and instructions on the use of the technique.

One important feature of the Fourier transformation is illustrated by the so-called Parseval Theorem, given as:

$$\int_{-\infty}^{\infty} f^2(t) dt = \int_{-\infty}^{\infty} \left| F(\omega) \right|^2 d\omega$$

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The Parseval Theorem states that the energy of the time signal f(t) can also be computed, using the Fourier transformation $F(\omega)$. $|F(\omega)|^2$ is also known as the signal f(t)'s energy spectrum.

Since one generally has only limited time at one's disposal, while the Fourier integral, conversely, calls for integration from $-\infty$ to ∞, we must resort to some simplifications. We can't wait forever for the Fourier transformation's result, nor do we have unlimited memory in which to store the continuous function f(t) to an infinite degree of precision. One way around the problem is the Sampling Theorem, which states that a band-limited signal f(t) with the upper band limit B can be reconstructed without error from sampling at the rate $f_T > 2B$. The frequency $f_T = 2B$ is called the Nyquist frequency.

We can thus sample the signal f(t), band-limited below B, at a finite number of points without losing information, if the Sampling Theorem's conditions are met.

We have thus limited the Fourier transformation in its time and frequency domain, which gives us a finite window of observation in terms of both time and spectra.

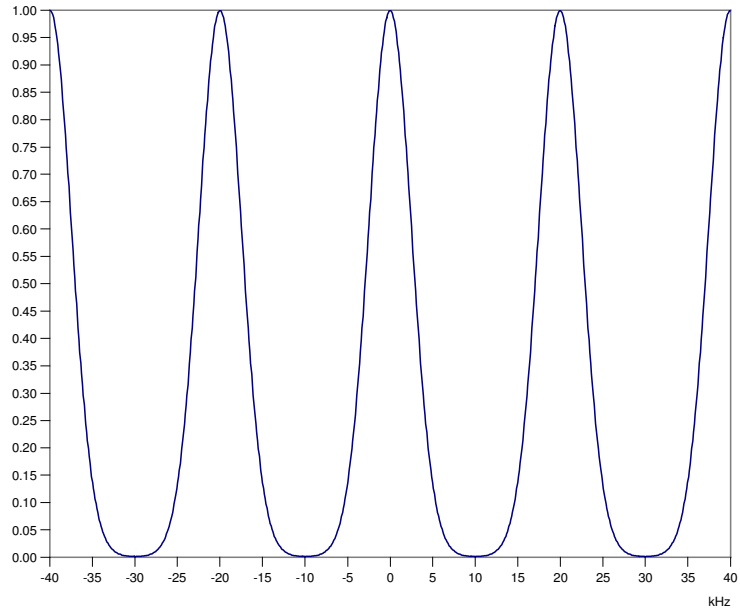

Fig. 91: Band-limited spectrum (f_T=20kHz)

The dashed line represents the signal's continuous Fourier spectrum. The periodic continuation of the spectrum results from the sampling in the time-based signal.

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As a practical rule, the signals are limited in time but not in the frequency domain. Thus, while the run-out of a machine is of limited duration, the band limits of its bearings' vibration are usually unknown. This means, however, that the sampling frequency must be set high enough to fulfill the conditions for the Sampling Theorem.

But what happens if the Sampling Theorem conditions are not met; if the sampling frequency is set too low?

With the sampling frequency too low, the spectra overlap at the edges, since the spectra's spread remains constant while the periodicity changes.

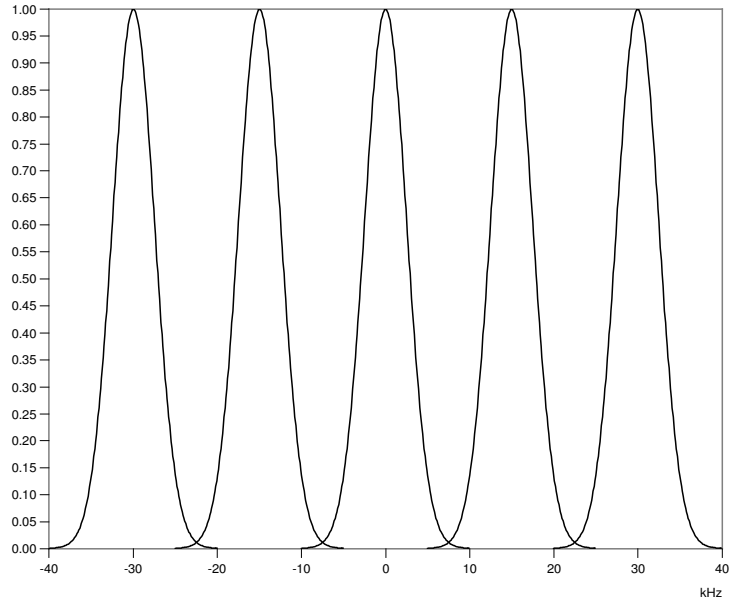

Fig. 92: Under-sampled spectrum (f_T=15kHz)

The overlapping spectra lead to incorrect interpretation and reconstruction of the time signal.

These effects of frequencies being reflected back are known as aliasing distortions. To avoid them, if the signal has no know band limits it is limited artificially before sampling is performed, using an analog front-end filter. This filter limits the bandwidth to a frequency of $f \leq \frac{f_T}{2}$.

Now we have a band-limited, discrete input signal fulfilling the Sampling Theorem conditions. Continuous Fourier transformation is replaced by discrete Fourier transformation, which can be accomplished by a computer in a finite amount of time.

Discrete Fourier transformation is defined as follows

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$$F_k = \sum_{n=0}^{N} f(n) e^{-jn\Omega k}$$

$$f(n) = \frac{1}{N} \sum_{n=0}^{N} F_k e^{jn\Omega k}$$

with

$$\Omega = \frac{2\pi}{N}$$

Converting the time signal to a discrete signal leads to the spectrum continuing through the frequency domain in periodicity, and subsequently to periodical continuation through the time domain. As a practical matter, this means that a segment of a signal (of length N points) is used to calculate the spectrum by discrete Fourier transformation. This segment is transformed to a spectrum, which implies that outside the window of observation the signal looks just like it does inside, in other words, extended all the way to $-\infty$ and ∞.

This implied continuation of the signal and the resulting effects can be clarified with the help of an example.

We assume a simple sinusoidal oscillation. We clip out a segment of N points for calculating the spectrum by means of discrete Fourier transformation.

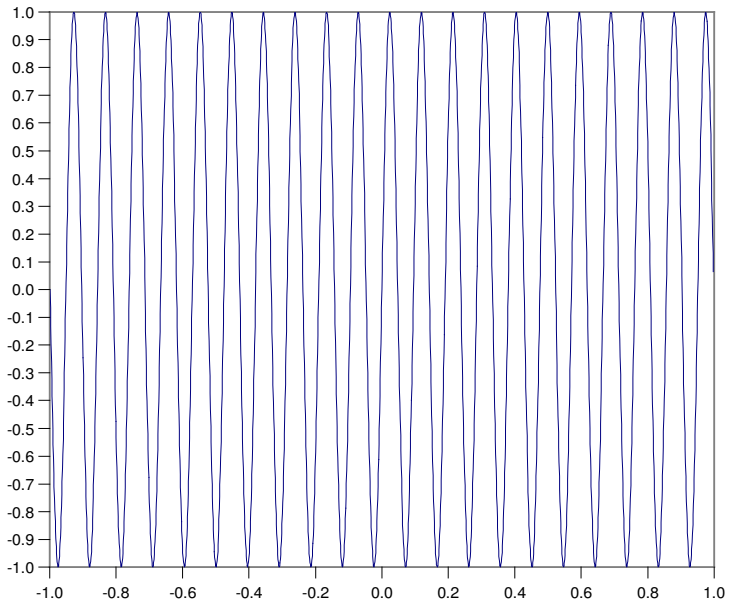

Fig. 93: Sine signal

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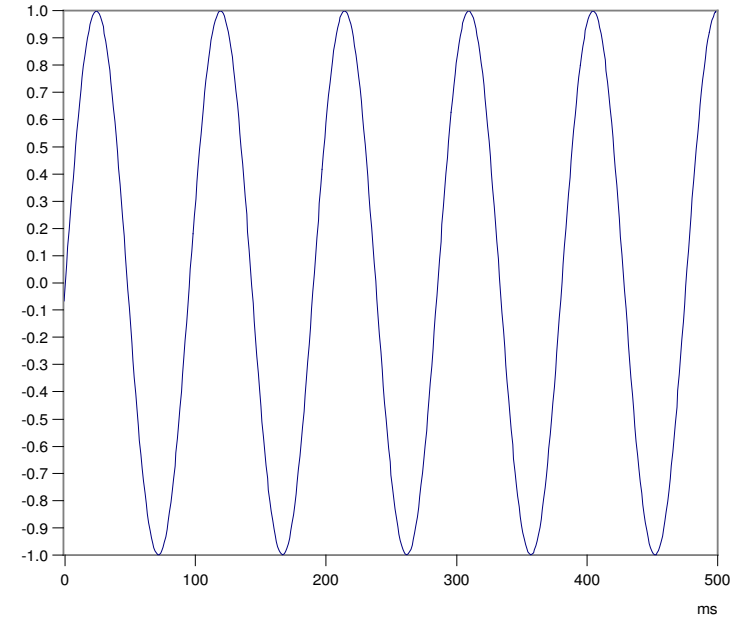

Fig. 94: Clipped sine signal for the FFT

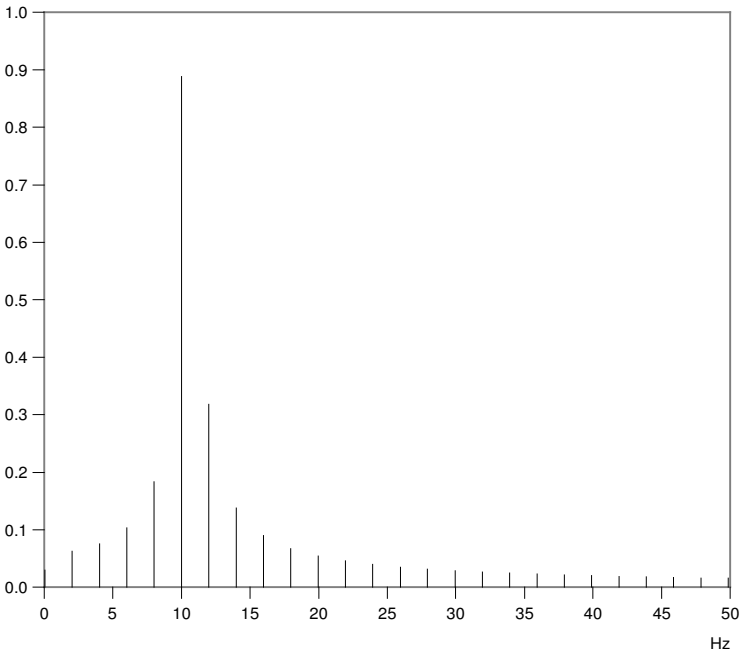

Fig. 95: Amplitude spectrum of excised signal

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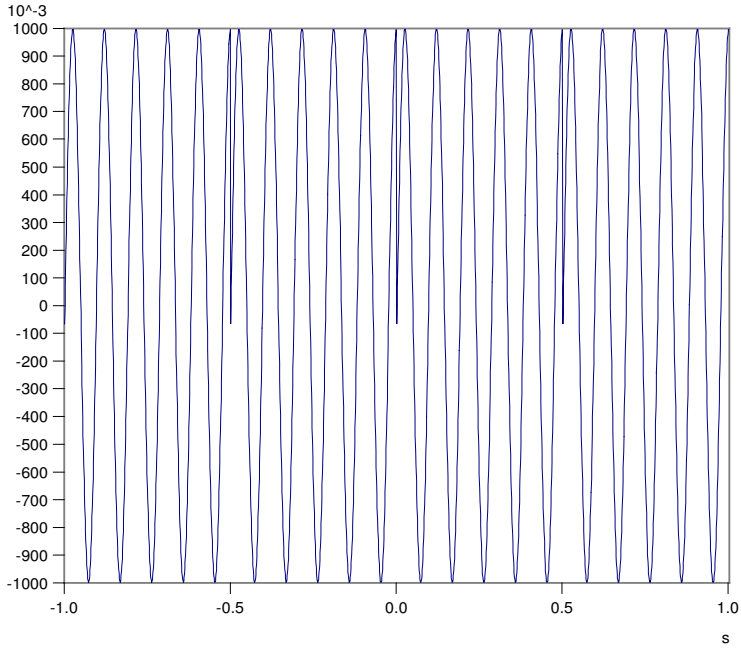

Fig. 96: Reverse-transformed spectrum of excised sine signal

The first figure shows the original sine signal. We clip out 5.25 periods of this signal for the purpose of calculating the discrete Fourier transform. The amplitude spectrum calculated is shown in the next figure, followed by the reverse transform.

What was to be expected?

The sine signal should have yielded a single spectral line at f= 10 Hz. Instead we obtain a spectrum "smeared" over a wide frequency range. When we view the signal's reverse transform, we can no longer recognize the original signal clearly; rather, we get a periodic continuation of the time signal segment which was clipped out.

In conjunction with clipping out a segment of the time-based signal, we have multiplied the sine signal with the weighting function

$$f_T(t) = f(t) * [\sigma(t) - \sigma(t-T)].$$

The function f(t) represents the sine signal, while the function $f_T(t)$ stands for the clipped-out segment. The function $[\sigma(t) - \sigma(t-T)]$ represents a rectangular window whose value is 1 within the time frame $0 \le t \le T$ and 0 outside it.

The rules for calculating the Fourier transform state that the spectrum of two time-based functions multiplied together can be expressed in the frequency domain as the convolution of two spectra.

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Appealing to the Distribution theory, the spectrum of the sine function is interpreted as a single line of frequency 10 Hz. The rectangular window's spectrum yields a SI-function taking the form $\frac{\sin(x)}{x}$. The overall spectrum corresponds to the convolution of the two spectra.

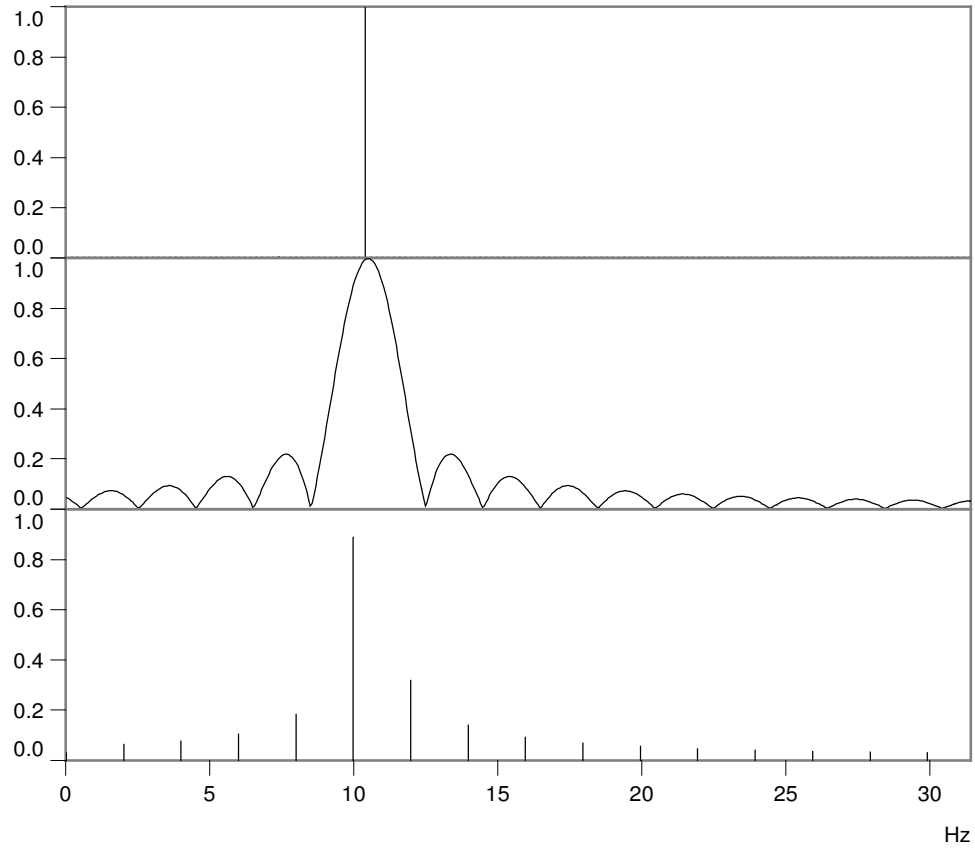

Fig. 97: Amplitude spectrum and result from convolution

These effects always appear when working with DFT. Note that there are a large number of different window functions aside from the rectangular function. However, there is a kind of fundamental uncertainty relationship when using window functions, which can be expressed as follows:

> *The more precisely the amplitude is determined, the less precisely the frequency is determined and vice-versa.*

Turkey and Cooley developed in 1965 an algorithm for performing DFT, which reduces the number of calculated segments from N^2 to $N \log(N)$ and is called the Fast Fourier Transform (FFT). It works especially quickly if N is chosen as a power of 2.

This concludes our introduction to the conditions for and the fundamentals of calculating an FFT.

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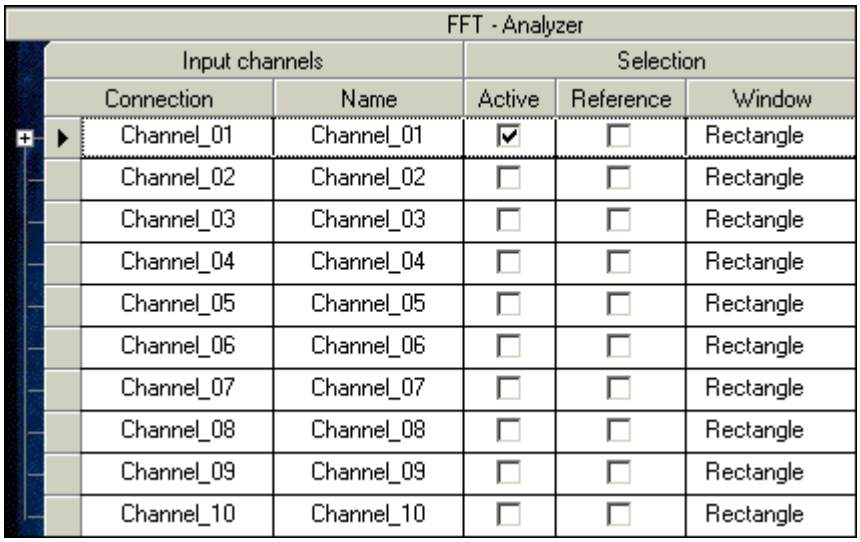
21.2 How to configure the Structure Analyzer

Call the interface for making settings for the Structure Analyzer by double-clicking on the heading "StructureAnalyzer" in the Project Explorer.



FFT - Analyzer

Input channels		Selection		
Connection	Name	Active	Reference	Window
Channel_01	Channel_01	☑	☐	Rectangle
Channel_02	Channel_02	☐	☐	Rectangle
Channel_03	Channel_03	☐	☐	Rectangle
Channel_04	Channel_04	☐	☐	Rectangle
Channel_05	Channel_05	☐	☐	Rectangle
Channel_06	Channel_06	☐	☐	Rectangle
Channel_07	Channel_07	☐	☐	Rectangle
Channel_08	Channel_08	☐	☐	Rectangle
Channel_09	Channel_09	☐	☐	Rectangle
Channel_10	Channel_10	☐	☐	Rectangle

Fig. 98: Structure -Analyzer settings dialog

You have the option to calculate a multiple different output channels for each input channel. Before configuring the output channels, we must first make the global settings for each input channel.

These settings include:

- **Active**
  This activates the input channel for the Structure Analyzer

- **Reference**
  Here you can determine which input channel serves as the reference channel for calculating transfer functions, coherence and cross power spectra. All other channels use this channel as the reference channel.

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- **Window**
  Window function used for the FFT; the following window functions are available:
  - Rectangle
  - Hamming
  - Hanning
  - Blackman
  - Blackman Harris
  - Flat Top
  - User defined

The user-defined window could be a force- or exponential window, however you wish. imc WAVE provides a special interface for this purpose, as described below. You can choose such windows after having designed them.

Setting the configuration can be accomplished by making entries directly into the table.

Next, you can configure the Structure Analyzer's output channels. First open up the list of output channels by clicking on the little "plus"-symbol at the head of a line in the table.

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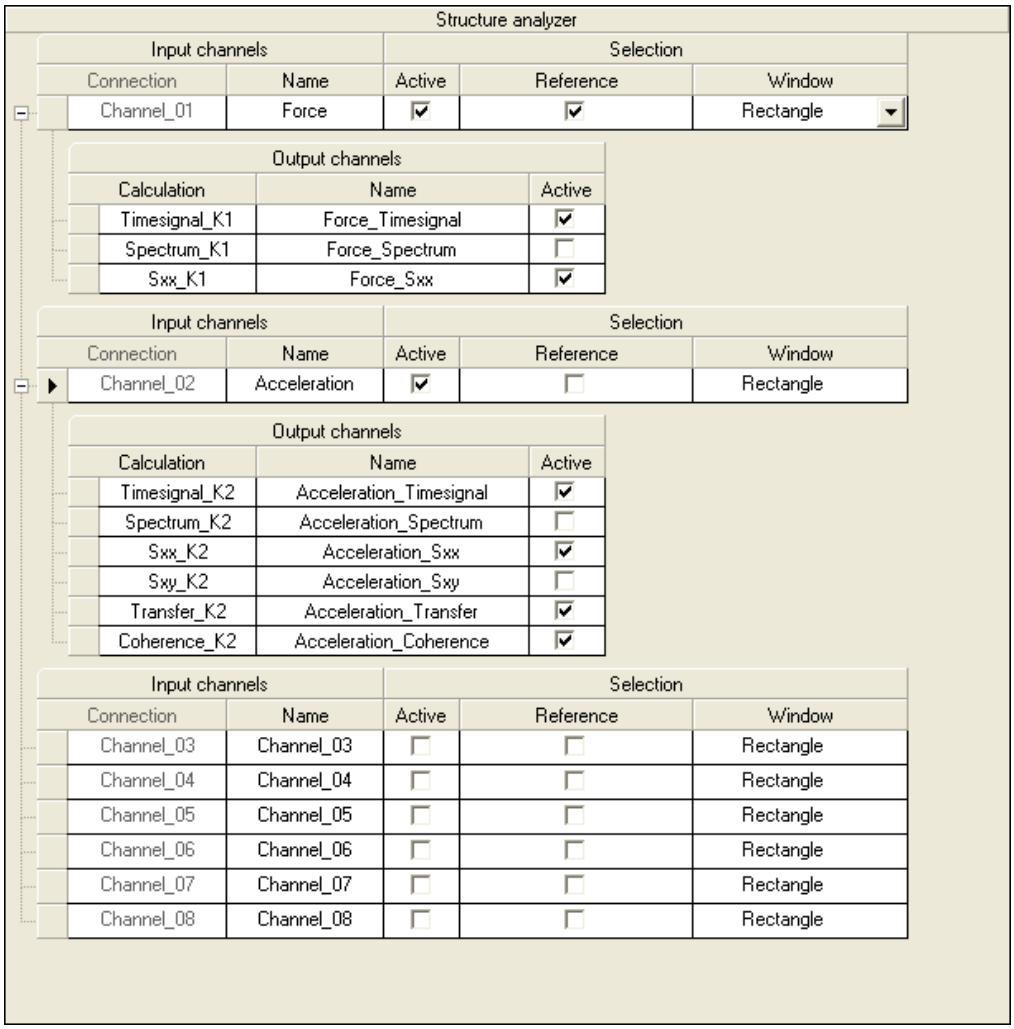

Fig. 99: Structure Analyzer output channels

The dialog then shows what output channels are available for the Structure Analyzer.

You can now activate and give names to the individual output channels. To do this, enter the name of the output channel desired. Activate it using the option button "Active".
The following output channels are available:

- **Time signal**
  Time behavior of the input signal

- **Spectrum**
  Complex spectrum of the input signal

- **Auto power spectrum**
  Auto power spectrum of the input signal

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- **Cross power spectrum**
  Cross power spectrum between the input and reference signal

- **Frequency response function**
  Frequency response function between the input and reference signal

- **Coherence function**
  Coherence function between the input and reference signal

Now activate the signals desired and prepare for measurement. This places the input and output channels at your disposal and you can construct the curve window and start a measurement.

This concludes the configuration of the input and output channels. You now have the option of setting the parameters for the Fourier transformation. To do this, click on the entry "Options", which is located in the Project Explorer below the heading "FFT-Analyzer".

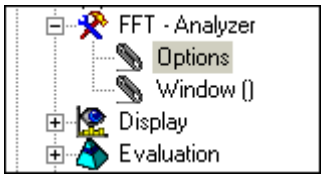

Fig. 100: Selecting the Structure-Analyzer's Options dialog

The following dialog then appears on-screen.

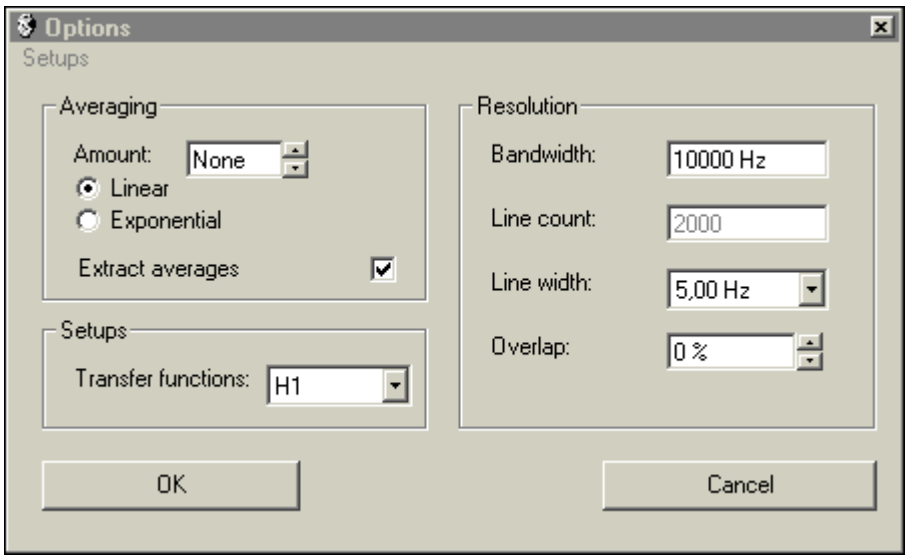

Fig. 101: Options dialog for the Structure-Analyzer

You can now set the various parameters for the FFT, averaging and transfer functions.

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Resolution

- Bandwidth
  The bandwidth determines the frequency range which can be used for the FFT. Within this frequency range, the FFT-Analyzer outputs the specified number of frequency lines.

- Line count
  Number of lines within the specified bandwidth outputted by the FFT-Analyzer.

- Line width
  Line width or also line distance within the bandwidth for the specified number of lines

- Overlap
  This means that the data sets used to calculate the FFT overlap each other. An overlap value of 0% means that there is no overlap, so that the data sets are each only used to calculate a single FFT. Overlap of 50 % means that the data sets from which each FFT is calculated half overlap each other. For instance, if an FFT with 512 points is calculated, the last 256 points are used to calculate the next FFT. This achieves good averaging, especially for strongly fluctuated signals.

Averaging

- Amount
  Enter here the number of averages to take in order to calculated the spectra

- Linear averaging
  Linear averaging corresponds to taking the arithmetic mean of individual spectra.

- Exponential averaging
  Exponential averaging weights current measurement results more than results which were recorded longer ago.

- Extract averages
  Check this button to extract the averaging results from the data stream

Setting the averaging is closely connected to the setting of the trigger. On this topic, please refer to the special chapter "FFT-Analyzer and trigger settings".

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Settings

- Transfer function
  The transfer function for measured data between two measurement points can be calculated in three different ways.

  H1: Gxy / Gxx: Measurement with noisy output signal, calculation by means of auto- and cross spectrum

  H2: Gyy / Gyx: Measurement with noisy input signal, calculation by means of auto- and cross spectrum

  H3: (Gxy / |Gxy |) * sqrt (Gyy / Gxx): Geometric mean of H1 and H2. The input and output are noisy.

Once you have made all desired changes you can close the dialog.

21.3 How to design your own window functions

For many measurement tasks involving the Structure-Analyzer, it's necessary for the data to be weighted using a window function, prior to applying the FFT algorithm. The relevant literature offers a wide variety of window function for various applications. imc WAVE provides a certain number of window functions. In addition, it's possible to adapt two window functions to your own purposes. These two window functions are the so-called force window and the exponential window, which are both mainly used for impact testing in Modal Analysis.

- Force window
  The power window is a rectangular window whose width and position within the data window can be set.

- Exponential window
  The Exponential window features exponential decay of the weighting, where the start time and the decay constant can be set.

To define one of the two windows, select the entry "Power window" below the heading "Structure-Analyzer" in the Project Explorer.

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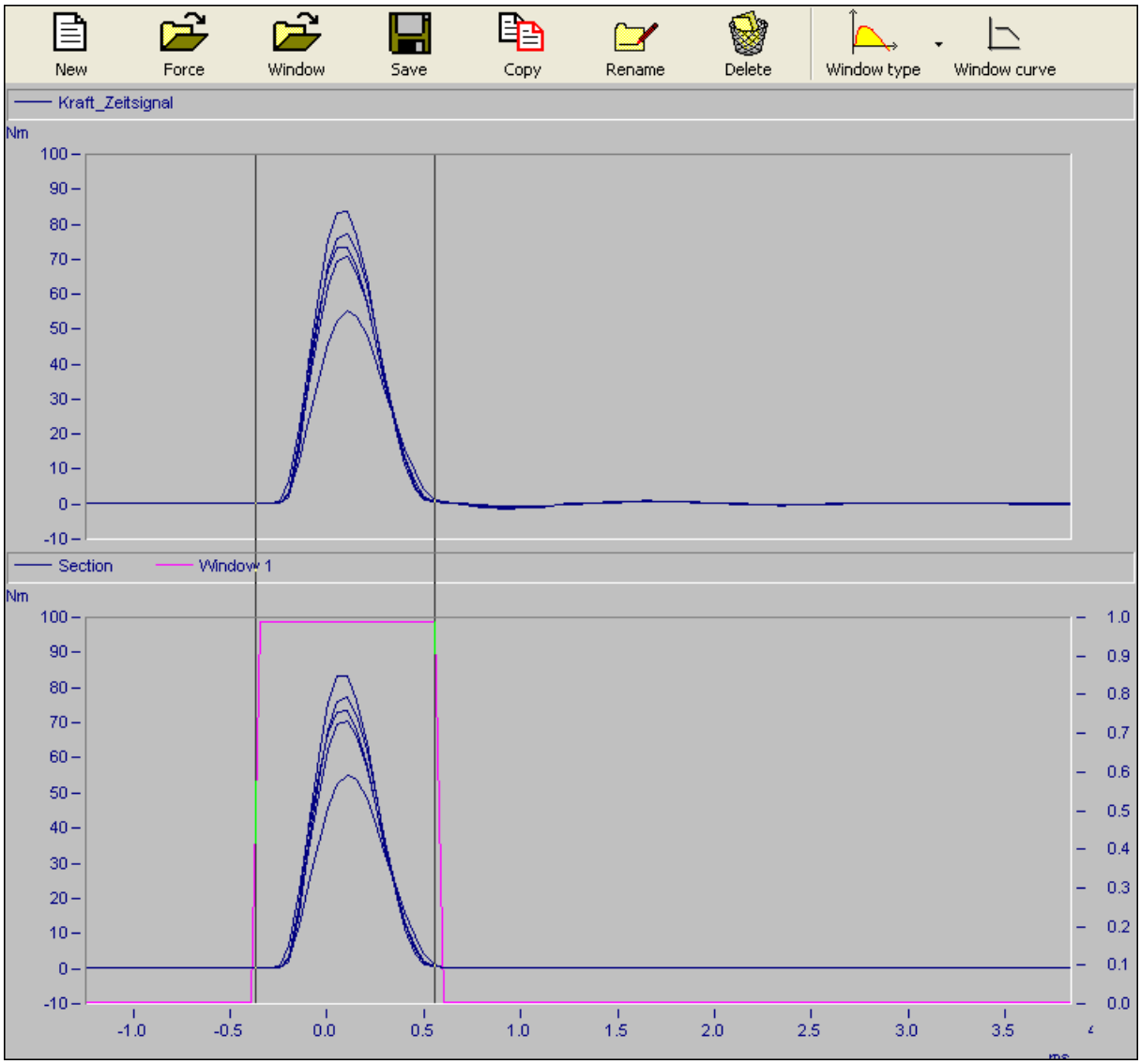

Fig. 102: Weighting-window design wizard for the force window and the exponential window

When you start the dialog, you are prompted to select a signal from the measured data, or the last one is loaded. The window function is applied to this signal.

The next dialog then contains two curve windows. In the upper curve window, a plot of the selected signal over time, as well as the desired window function, is seen. The lower curve window shows the signal's plot over time with the window function applied.

You can also select the desired window function by clicking on the button "Window type".
Next, you position the window function with the help of two cursors. In the figure above, an example of this featuring the force window is shown.

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The button "Window function" can be used at any time to display the designed window together with the signal in the lower window, making it possible to verify the window's data point-by-point.

Once you have designed your force window, you can save it and it is available for your use in the FFT-Analyzer.

The other toolbar buttons enable you to create, load, save, rename or delete window functions.

The picture below shows an example of a design for an exponential window.

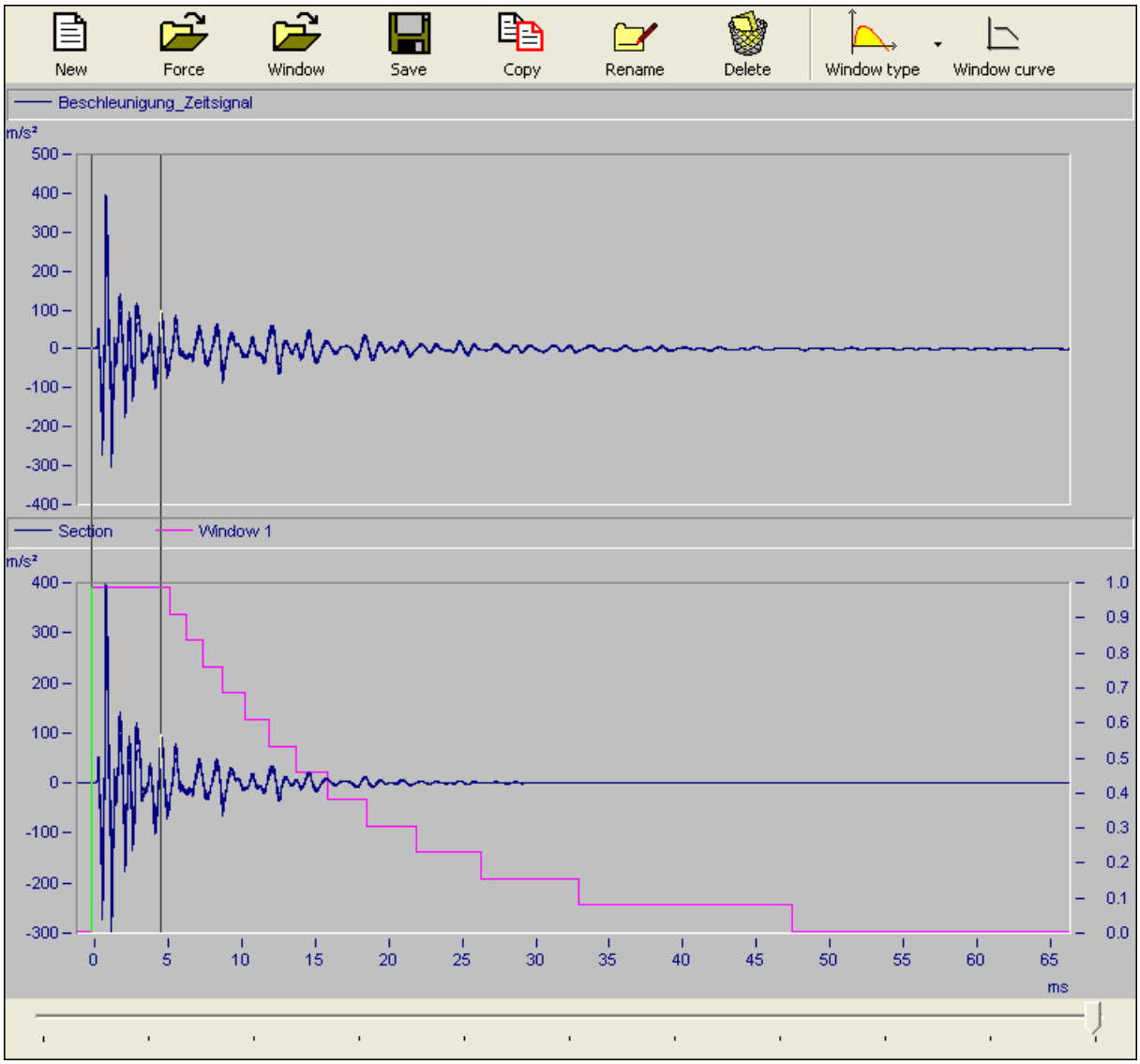

Fig. 103: Example of the design of an exponential window

When designing an exponential window, you have at your disposal not only the two cursors but also a scroll bar below the curve window. This scroll bar can be used to set the exponential rate at which window

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function decays. The effects of the settings are displayed for you right in the curve window.

21.4 Structure-Analyzer and trigger settings

The Structure-Analyzer and the trigger settings are closely linked. You thus have a large variety of settings options useful for helping you solve your measurement tasks.

Here are some short clarifications of terms used:

- Trigger
  A trigger is the mechanism which initiates data capture. Each release of the trigger causes data capture to begin. This data acquisition is called a recording.

- Recording
  A triggered data capture procedure is called a recording.

- Averaging
  Taking a mean value of the data from multiple runs is called averaging.

- Stopping measurement
  Ending a measurement such that the trigger is disabled and no further runs can be carried out is called stopping the measurement.

In principle, we distinguish between two different ways of accepting the measurement results:

- No acceptance
- Manual acceptance

Manual acceptance is used, for instance, for data capture by means of an impulse hammer for Modal Analysis. After every recording with Manual acceptance, the recording can be deleted again. This can be useful if, for example, a recording of an impulse hammer measurement wasn't carried out properly (double-stimulation, wrong striking position). The trigger's settings for this method remain intact.

Below, the different operating modes are contrasted, based on the case of one active time-domain channel and the corresponding channel of the power density spectrum Sxx. This example should serve to illustrate the operative principles.

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No manual acceptance

With this acceptance method, deleting the data when the recording ends isn't possible.

Operation Type 1:

Trigger:	none
Averaging:	none
Number of runs:	undefined

The measurement must be stopped manually.

The time-based signal is continuously captured since no trigger event is defined.

The signal Sxx is recorded as a segmented waveform, in which each segment corresponds to a power density spectrum.

Operation Type 2:

Trigger:	none
Averaging:	none
Number of runs:	5

The measurement stops automatically when the specified number of recordings has been performed.

The time-based signal is saved as a waveform with 5 events, where each event is a data recording.

The signal Sxx is saved as a waveform with events, each of which contains one segment representing the power density spectrum of one event from the original time-domain waveform.

Operation Type 3:

Trigger:	none
Averaging:	10
Number of runs:	undefined

The measurement must be stopped manually.

The time-based signal is continuously captured since no trigger event is defined.

The signal is saved as a segmented waveform in which each segment

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represents the average over 10 power density spectra. In other words, an average is taken of each group of 10 power density spectra. Instead of a moving average, the average is taken of a window of fixed size with 10 spectra. The intermediate results of the averaged spectra are outputted continuously. After the specified number of averages, the averaging result is reset and the process starts over.

Operation Type 4:

Trigger:	none
Averaging:	10
Number of runs:	5

Measurement stops automatically once the specified number of 50 recordings has been completed.

The time-domain signal consists of 50 events.

The signal Sxx is recorded as waveform with 5 events. Each event consists of one segment formed as the average from 10 power density spectra. In other words, an average is taken of each group of 10 power density spectra. Instead of a moving average, the average is taken of a window of fixed size with 10 spectra. Only every tenth spectrum is returned.

Operation Type 5:

Trigger:	active
Averaging:	none
Number of runs:	undefined

The measurement must be stopped manually.

The time-domain signal is recorded as a waveform with events, each of which represents one data acquisition. The number of events depends on the length of the data capture.

The signal Sxx is saved as a waveform with events, each of which contains one segment representing the power density spectrum of the corresponding event in the time-domain signal.

Operation Type 6:

Trigger:	active
Averaging:	none
Number of runs:	5

The measurement stops automatically.

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The time-based signal is saved as a waveform with 5 events, where each event is a data recording.

The signal Sxx is saved as a waveform with events, each of which consists of one segment representing the power density spectrum of the corresponding event in the time-domain signal.

Operation Type 7:

Trigger:	5
Averaging:	10
Number of runs:	none

Measurement must be stopped manually.

The time-domain signal is recorded as a waveform with events, where each event represents one data acquisition. The number of events depends on the data acquisition's length.

The signal Sxx is recorded as a segmented waveform. The number of segments depends on how long the data acquisition runs, where each segment represents the average power density spectrum of 10 events. Every result of the averaging of the power density spectra is outputted. After 10 events, the averaging result is reset and the process starts over.

Operation Type 8:

Trigger:	5
Averaging:	10
Number of runs:	5

Measurement stops automatically.

The time-domain signal is recorded as a waveform with 50 events, where each event represents one data acquisition.

The signal Sxx is recorded as waveform with 5 events. Each event consists of one segment formed as the average from 10 power density spectra. In other words, an average is taken of each group of 10 power density spectra. Instead of a moving average, the average is taken of a window of fixed size with 10 spectra. Only every tenth spectrum is returned

Manual acceptance

Manual acceptance is only possible for triggered measurements, otherwise the Options button appears as disabled.

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When Manual acceptance is active, the number of averages is no longer specified in the Structure-Analyzer's Options dialog, but rather in the Trigger dialog.

21.5 Application example: Modal Analysis

Modal Analysis is a tool for investigating the dynamic behavior of structures. This behavior can be interesting for a variety of reasons, for instance, if it

1. is uncomfortable,
2. is difficult to control,
3. is subject to fatigue, or
4. produces too much noise.

Oscillation analysis is able to clarify the following questions:

1. How much does the structure move?
2. Where does it move?
3. How does one point move in relation to another point?
   In this context, the term Operating Deflection Shape is often used.
4. Does the motion coincide with a resonance, and how does the mode move at that position?
5. Can the noise or vibrations be reduced by some means?

This is only a sample of the questions which structural vibration analysis can answer.
Oscillation analysis regards two types of oscillations,

1. externally driven oscillations, e.g. due to external loads or unbalances, and
2. vibrations due to resonances, e.g. excitation at natural modes.

Vibrations are generally a combination of these two types. The driven vibrations correspond to the operating deflections, and the resonance vibrations correspond to the modal oscillations (modes).

The resonance oscillations come about when energy is caught within the structure and oscillates back and forth between the boundaries of the structure.
A bell is a good example of a structure that traps energy. When a bell is struck, the energy courses back and forth between the structure boundaries and slowly decays by being transferred to the environment and through inner damping. Standing waves of fixed frequency form in

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the structure, so-called mode shapes. In such mode shapes, the energy is shifted back and forth between potential and kinetic energy.
The frequency, damping and form of the structure's motion all depend on the structure's material. The mode shapes are the dominant forms of motion at the respective resonance frequencies.

Modal Analysis is thus a tool for determining the structure's dynamics on the basis of the modes. For this purpose, the structure's resonances in the relevant frequency range and the associated damping values are determined, and the forms of motion are calculated. The modes are the forms of motion at modal frequencies and the modal damping values.

One prerequisite for using Modal Analysis is that the structure under investigation behave linearly. However, good approximate results can also be achieved for slightly non-linear structures.
Performing Modal Analysis entails deriving an idealized mathematical model from the real-life structure. The idealized model in turn is based on differential equations. Toward this end, the real-life structure is replaced by a system of m point masses. These point masses are connected with each other by springs and viscous dampers. The model's equations of motion can be described by a coupled system of 2nd order differential equations.

The mathematical formulation is given by the following

$$M\ \ddot{x}(t) + C\ \dot{x}(t) + Kx(t) = f(t)$$

where

x	time plot of the amplitude
M	Mass
C	Damping
K	Stiffness
F(t)	Course of the external forces over time

The quantities M, C and K are matrices. The motion quantities x and F are vectors. The matrices are symmetric as a matter of principle.

Modal Analysis' task is to determine the unknown parameters of this differential equation M, C, and K. The above equation cannot be used directly to solve this problem, since the equations are coupled and thus mutually affect each other.

To solve this problem, mathematics provides the far-reaching theory of modal transformation, which is based on solving the eigen-value problem. Toward this end, proportional or Rayleigh damping is taken as given.

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Starting from this assumption, it is possible to diagonalize the individual matrices and thus to separate them, enabling us to determine the transfer function between the individual transfer functions.

$$H_{ik} = \sum_{p=1}^{M} \frac{\Phi_{ip}\Phi_{kp}}{-\Omega^2 + j2\xi_p\Omega\omega_p + \omega_p^2}$$

This transfer function describes the transfer from the k[th] to the i[th] mass point by way of the frequency Ω. The unknown quantities $\Phi_{ip}, \Phi_{kp}, \xi_p, \omega_p$ must now be determined by measurement.

For that purpose, the structure is overlaid with a grid of measurement points, where the amount of grid points matches the modal degrees of freedom and each grid point corresponds to a measurement point. There are then a number of ways to carry out the measurement for determining the modal parameters. The procedures introduce defined forces into the structure at one or more points and find the structure's response at the other points.

1. Constant application of force
   The force f(t) is applied at the same point in all measurements and the sensors for determining the structure response are attached to the respective response points.

2. Measurement of the structure response at a constant point
   Since the system matrices are constant, it is also possible to invert the above procedure. Toward this end, the force application point moves around the structure while the structure response is measured always at the same point.

Both methods return the same results if properly carried out. However, either one of the procedures may be more advantageous for a particular structure, or return more precise results (for instance, with a curved structure surface, it may not always be possible to apply the force exactly vertically, so that in such a case, the first procedure is preferable).

The measurement can now be carried out either with an impulse hammer or with a shaker. Depending on how your analyzer is equipped, the plots of the stimulation and response signals over time are recorded for the appropriate points, and the corresponding transfer function determined. The measurement must be carried out for every relevant point. The resulting transfer functions can then be used to derive the modal parameters, which ultimately model the forms of the structure's motion.

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Applications of modal analysis

1. Verification of analytical models
   The results from FEM calculations can be verified by means of an experimental modal analysis. If the model and the measurements agree, the analytical model can be used for further simulations.

2. Help in solving noise and vibration problems
   The forms of the structure's motion can be used to deduct the noise's and vibrations propagation paths and forms of reflection.

3. Structure modification
   Evaluation of structural modifications to remedy vibration and noise problems

Thus, Modal Analysis provides a tool for solving a variety of problems.

The procedure can be outlined as follows:

1. Establish the necessary environmental conditions for the structure under investigation

2. Define test points

3. Attach sensor or shaker to structure

4. Configure measurement system for the task

5. Measure the transfer functions at the defined measurement points

6. Create a 3D model of the structure

7. Display the operating deflections with the help of the recorded transfer functions

8. Estimate the modal parameters from the recorded transfer functions

9. Display the modes

After carrying out this procedure for Modal Analysis, imc WAVE and a Modal Analysis program such as the company Vibrant Technologies' ME´scope can be used to investigate the structure.

Below, a relatively simple structure shall be used to illustrate the individual steps.

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Fig. 104: Structure for the modal testing

The structure is laid on a soft plastic foam material in order to ensure adequate isolation from the table surface and thus to avoid distortion of the measurement results. The test points are marked with a pen on the Measuring object's surface. The selected measurement points are:

23, 27, 44, 48, 53, 69

and the selected response point is: 65.

The measurements are performed with an impulse hammer and an accelerometer which is firmly attached to a point on the structure. The accelerometer is attached on the structure's bottom side, so that the impulse hammer will be able to stimulate it at its measurement point. Attachment on the bottom means a reversal of the sign of the acceleration data, which can be compensated in the measurement system by a scaling factor.

Capture of the measurement data is performed by imc WAVE. The sensors are loaded via the sensor database and the channels are configured

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accordingly. Then we configure the trigger on the impulse hammer's force channel so that the measurement is only triggered when the threshold set has been exceeded. We also set a pretrigger of 10 ms so that the stimulating impulse lies within the recording's window.

For the purpose of noise suppression, five measurements per measurement point are carried out, of which the linear average is taken automatically by the measurement system. The quality of the measurement is checked by means of the coherence function.

It is now possible to carry out the measurement. The measurement system is started, the impulse hammer supplies the stimulus at the desired point and the data are recorded at the response point. This measurement is repeated for each stimulus point.

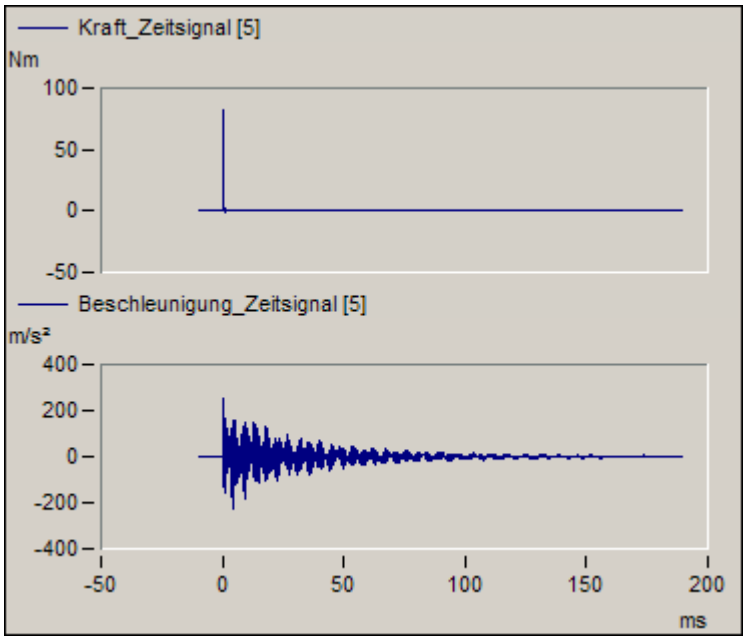

Fig. 105: Plots of the stimulus and response signals

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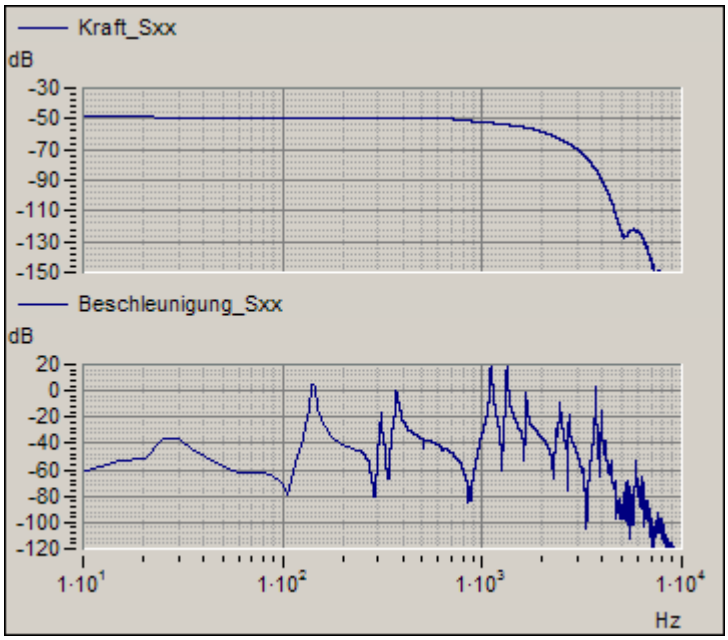

Fig. 106: Power density spectra of stimulus and response signals

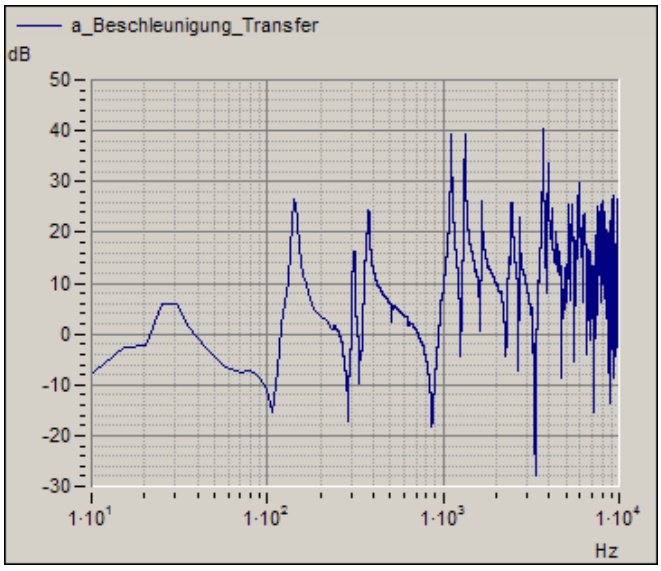

Fig. 107: Transfer function between stimulus and response points

After completing the measurement, we turn to the Modal Analysis program ME´scope and create a 3D model of our structure.

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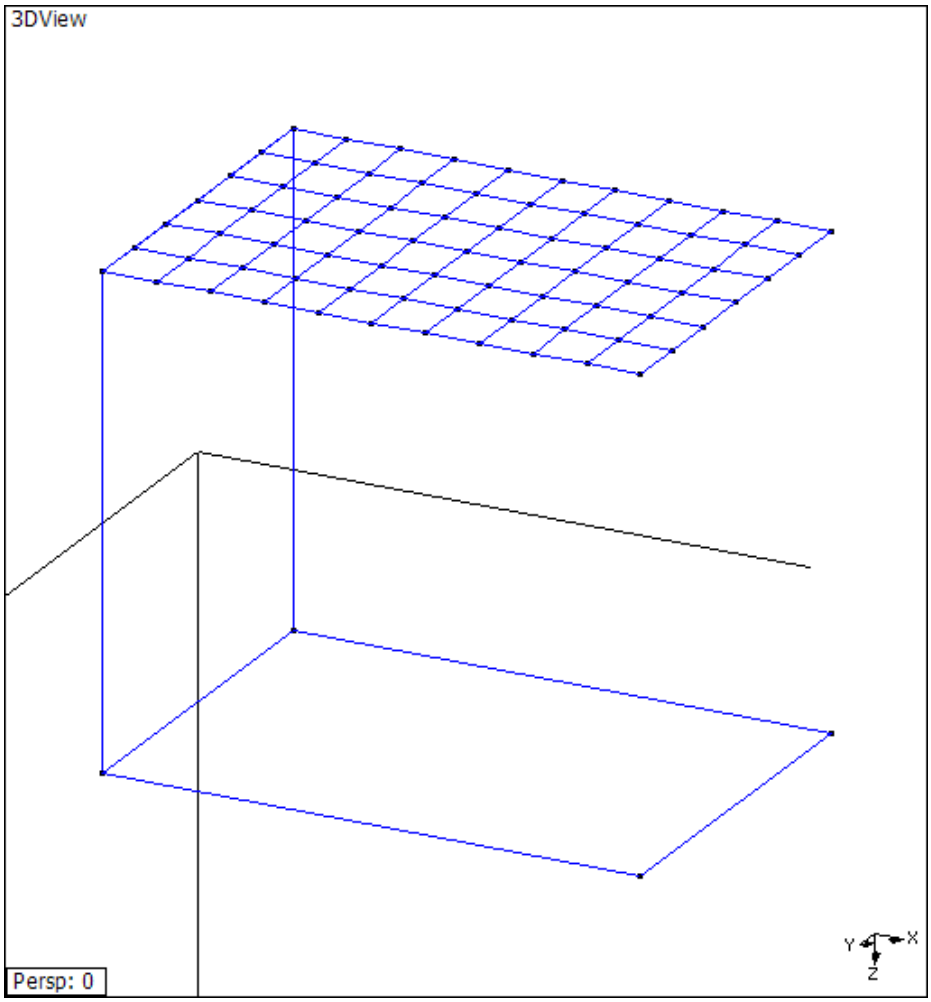

Fig. 108: 3D model of the structure

The points defined for the structure are numbered.

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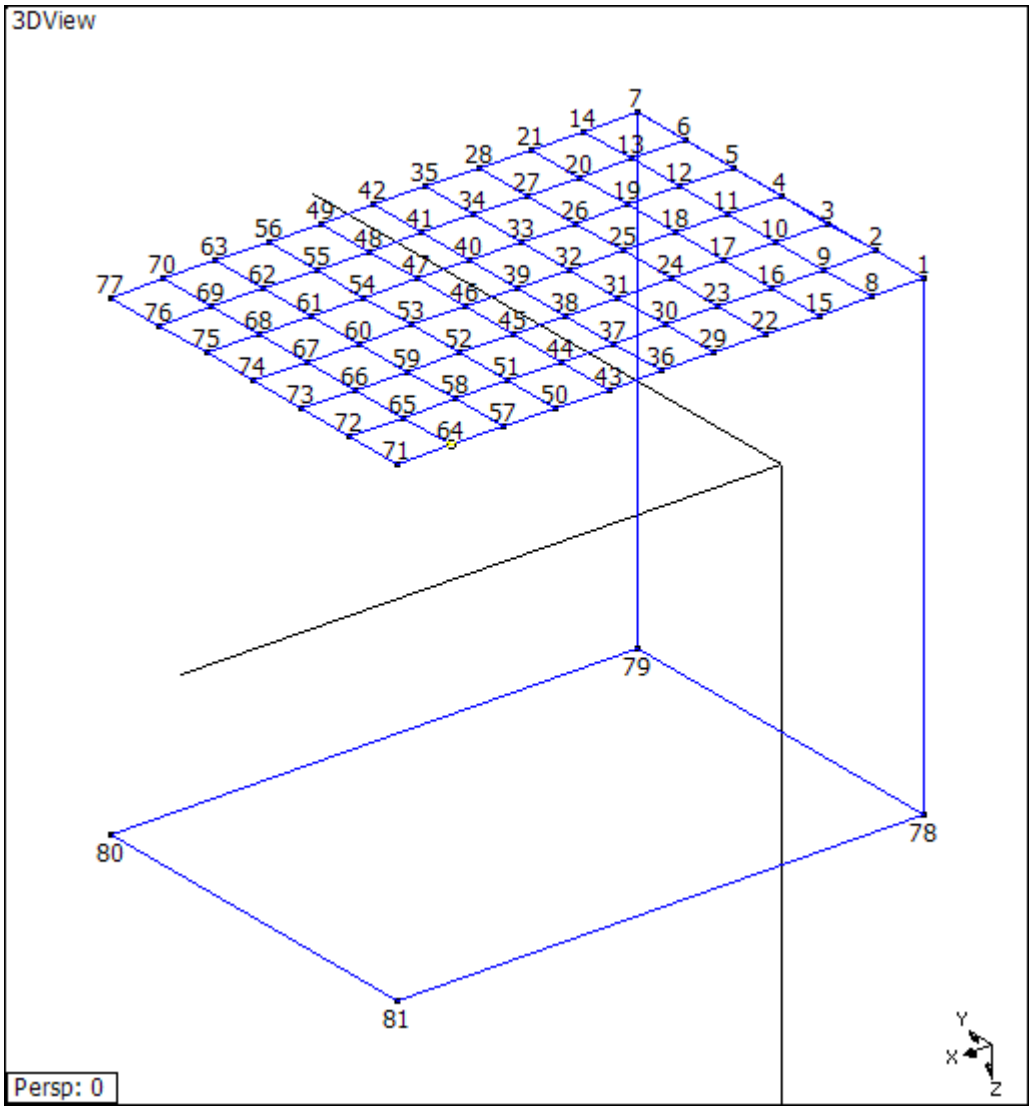

Fig. 109: Designation of the structure model's points

Next, the measurement results are assigned to the points defined in the Modal Analysis program. This procedure is dependent upon which Modal Analysis program is used. In ME´scope's case, it is a simple loading procedure, since ME´scope can read imc WAVE's file format in directly, while imc WAVE in turn can directly write in ME´scope's file format.

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It is thus already possible to view the structure's operating deflection.

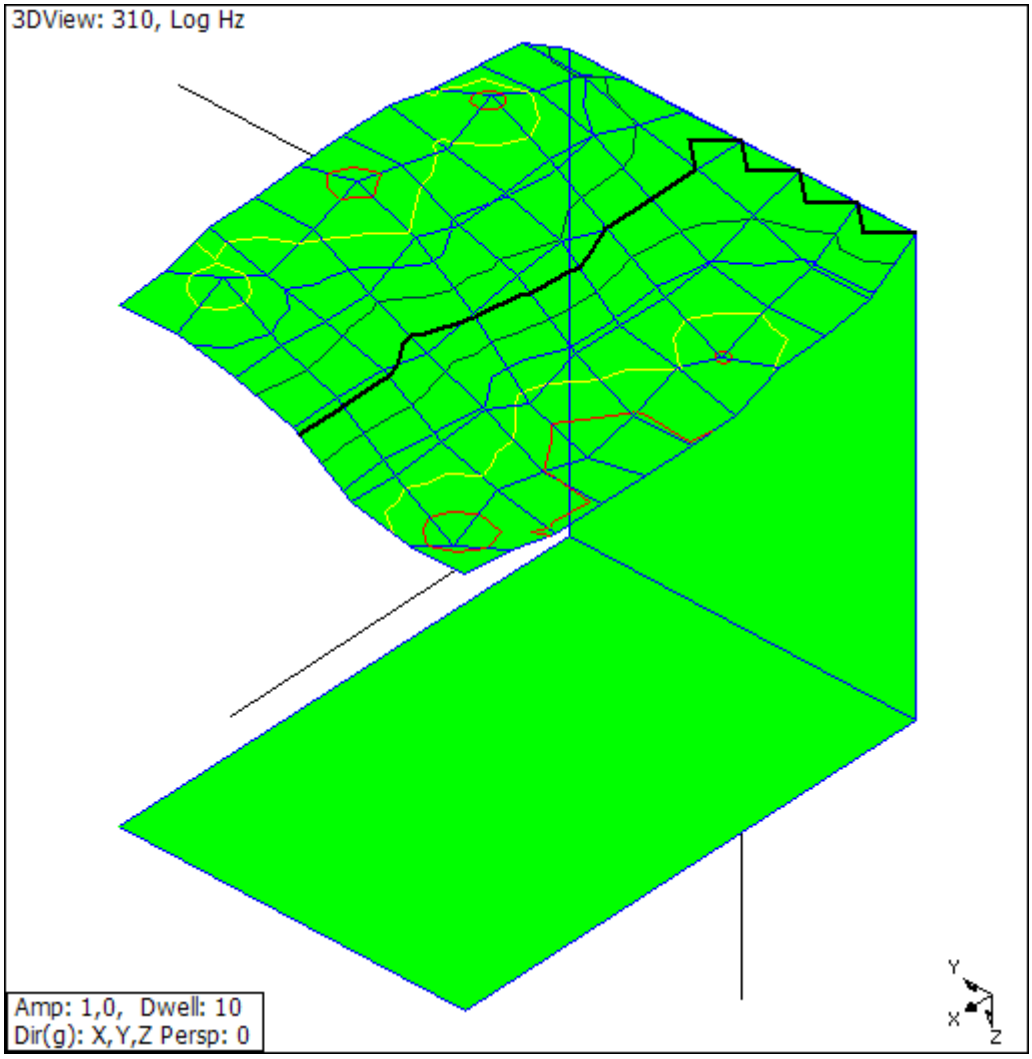

Fig. 110: Operating deflection shape of the structure at 315 Hz

ME´scope is then able to determine the transfer functions directly from the modal parameters, which are recorded in a table.

The mode of the operating deflection shape shown above is represented in the figure below.

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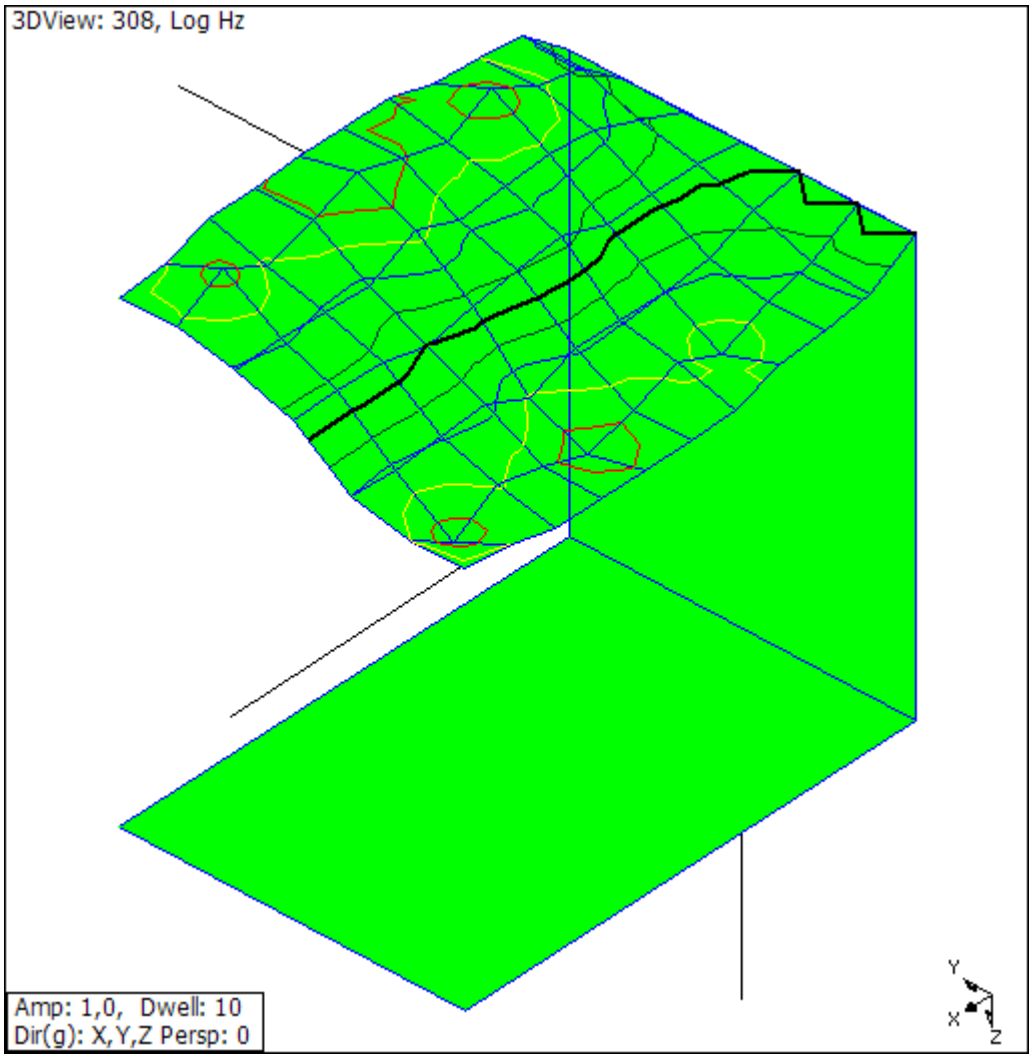

Fig. 111: The structure's mode at 310 Hz

The images are only slightly different, since as we already noted, the form of the motion near a modal frequency is dominated by the corresponding mode.

The investigated structure's first three modes were determined as per the following table.

Shape	Label	Frequency	Damping	Units	Damping (%)	Color
1	GPO:PO	143,	1,23	Log Hz	0,865	
2	GPO:PO	308,	1,96	Log Hz	0,635	
3	GPO:PO	373,	4,56	Log Hz	1,22	

Fig. 112: Parameters of the first 3 modes of the investigated structure

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22 The Sound Power Analyzer

The Sound Power Analyzer uses a strictly formulated procedure to calculate the sound power according to a selectable standard. Towards this end, the third-octave and octave spectra are calculated by an ONLINE-DSP in the measurement device. These spectra are converted to a sound power rating according to the standard you select. It is possible to display and print out the intermediate results.

The settings for the Sound Power Analyzer are specific to a particular project.

22.1 What is sound power?

As a part of regulatory harmonization within the European Community, as well as in the spirit of increasing ecological consciousness, inspection of the acoustic properties of machinery is gaining importance or is even legally mandated. For instance, Guideline 2000/14/EG of the European Parliament and Council, dated 8th of May, 2000, regulates the assimilation of member countries' law on noise pollution from machinery designed for outdoor use. This guideline stipulates the test procedures and value limits for a number of machines operated outdoors. The test procedures are generally based on a measurement of the sound power, which in contrast to acoustic pressure measurement does not depend on the distance from the source to the microphone. Also, the sound power measurement procedures are in the first approximation still immune to any influences of the measurement room and of external disturbing noise. This means that measurement results for two different devices or machines can be compared directly, wherever they were measured. This makes it possible, in particular, for one to purchase a selected product from among many similar ones based on the acoustic power emitted.

The sound power of an acoustic source (machine, device) is defined as

$$P = \int_S \vec{I}\, \vec{dS}$$

where I represents the vectorial sound intensity, which is derived from the acoustic pressure and the vectorial sound particle velocity v

$$\vec{I} = p\, \vec{v}$$

which yields for the sound power P

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$$P = \int_S p \vec{v} \vec{dS}$$

Thus, the sound power is obtained by integrating the sound intensity or the product of p v over any enclosing surface.
The scalar product $\vec{I}\,\vec{dS}$ or $\vec{v}\,\vec{dS}$ ensures that it is always only the sound intensity or sound velocity component which is perpendicular to a surface segment that contributing to the power calculation.

The common standards, which calculate the sound power by assuming an enclosing surface around the measuring object, basically divide the integral of the enclosing surface into discrete partial surfaces, and take a acoustic pressure measurement for each of these partial surfaces, in conjunction with the acoustic impedance

$$Z = \frac{p}{v}$$

To determine the sound power as

$$P \approx \sum_i S_i p_i v_i = \sum_i S_i \frac{p_i^2}{Z}.$$

The acoustic impedance Z can be stated for a presumptive wave type.

- Flat wave

  $Z = \rho c$

  ρ = density of medium
  c = sound particle velocity in medium

- Spherical wave

  $$Z = \rho c \frac{jkr}{1 + jkr}$$

  ρ = density of medium
  c = sound particle velocity in medium
  k = wave number
  r = radius of spherical emitter

It is thus possible to determine the sound power from the acoustic pressure for familiar wave fields.

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The acoustic pressure-based envelope curve method assumes that the emitting object can be approximated by a 0^{th} order spherical emitter. Such a 0^{th} order spherical emitter can be imagined as a breathing ball. Its acoustic impedance approaches the impedance of a spherical wave for

$$kr \to \infty \ ,$$

thus approaching a real-world impedance. This also causes the sound particle velocity and acoustic pressure to be in phase, so that the phase difference between velocity and pressure can be neglected when calculating the sound intensity.

For practical applications, the above-mentioned condition can be replaced by the condition

$$kr >> 1 \ ,$$

from which it follows that

$$r >> \lambda \ .$$

This condition requires that the distance from the test object to the microphone must be much greater than the longest wavelength and thus the smallest frequency to be investigated.

If the measurement is carried out inside rooms, the rooms' acoustic properties must be taken into consideration. Besides the ratio of the room size to the test object's size, the sound field distribution and frequency response are also of interest. Depending on the required precision, the standards use correction quantities to allow for the influence of these quantities. The standards define measurement procedures for determining the correction quantities, or refer to other standards.

To measure the acoustic pressure emitted and calculate the sound power level, a number of microphones are distributed over a measurement area and the mean acoustic pressure on the measurement area is determined. To correct for extrinsic noises, the acoustic pressure levels is recorded both when the machine is on and when it is off, and the difference of the signals is calculated according to a defined algorithm.

Besides the acoustic pressure measuring envelope curve method, there are other procedures which determine sound power in an echo chamber. For this purpose, the microphones must be distributed in the sound source's diffuse field.

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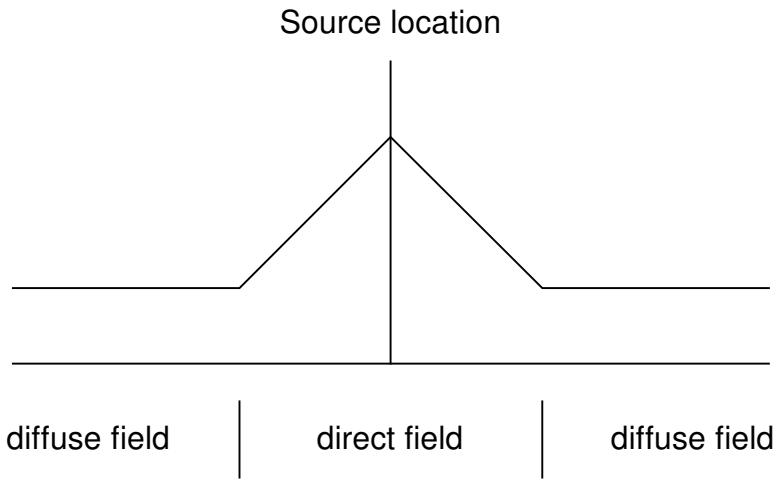

Fig. 113: Sonic field in an echo chamber

The diffuse field forms in an enclosed room with sound-reflecting walls beyond a distance from the source of wavelength λ, which corresponds to the lowest frequency of interest. The echo chamber must also meet other requirements such as the minimum volume

$$V_{\min} = \left(\frac{1000}{f_{\min}} \right)^3 ,$$

as well as being equipped with reflectors designed to promote the homogeneity of the diffuse field.

The sound power is again determined using the mean acoustic pressure over a variety of microphone locations.

The procedures for determining sound power from the acoustic pressure are standardized by various standards having various constraint conditions. The table below presents an overview of the different fields of application (taken from Weck and Melder: Maschinengeräusche Messen, Beurteilen, Mindern, VDI-Verlag, Düsseldorf 1980)

	Test Class	Operating class	Precision Class
laboratory			ISO 3745
sound-reflecting floor	ISO 3746	ISO 3744	
large room			
machine room			
echo chamber		ISO 3743	
special echo chamber			ISO 3741/3742

Fig. 114: Applicability of different procedures to sound power measurement

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In addition to the procedures for determining the sound power via the acoustic pressure, there are also procedures for directly measuring the sound intensity.

As mentioned further above, the sound intensity is defined as the product of acoustic pressure and the sound particle velocity

$$\vec{I} = p\,\vec{v}$$

To measure the sound intensity directly, it is necessary to measure the sound particle velocity with the correct sign, which is very difficult.

One approach for achieving measurement of the sound particle velocity indirectly uses the linearized balance of impulse equation

$$\rho_0 \frac{\partial v}{\partial t} = -grad(p)\,.$$

Integrating this equation over time yields

$$v(t) = -\frac{1}{\rho_0}\int_{-\infty}^{t} grad\big(p(\tau)\big)d\tau\,.$$

Now we consider just one of the vector v's components and obtain the following simplified equation

$$v_x(t) = -\frac{1}{\rho_0}\int_{-\infty}^{t} \frac{\partial p(\tau)}{\partial x}\,d\tau\,.$$

If the pressure gradient $\frac{\partial p}{\partial x}$ is approximated in the x-direction by measuring at two points, we obtain the approximation

$$v_x(t) \approx -\frac{1}{\rho_0}\int_{-\infty}^{t} \frac{p_{x1}(\tau) - p_{x2}(\tau)}{\Delta x}\,d\tau$$

where

p_x = acoustic pressure at the points x

Δx = distance between the acoustic pressure measurement points

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The approximation of the gradient by means of two-point measurement is only valid for a limited frequency range. The wavelength of the highest frequency considered must conform to the relationship

$$\lambda >> \Delta x$$

so that the pressure difference is not distorted by the wave's pressure fluctuations.

We thus see that the sound particle velocity can be approximated by means of acoustic pressure measurement at two points. The acoustic pressure required for computing the sound intensity is determined as an arithmetic mean by using the two microphones.

$$p(t) = \frac{\left(p_{x1}(t) + p_{x2}(t)\right)}{2}$$

Thus, the sound intensity in the direction x is given by the equation

$$I_x(t) = p(t)v_x(t) \approx -\frac{1}{2\rho_0 \Delta x}\left(p_{x1}(t) + p_{x2}(t)\right)\int_{-\infty}^{t}\left(p_{x1}(\tau) - p_{x2}(\tau)\right)d\tau$$

This equation is used to compute the sound intensity from an acoustic pressure measurement at two points.

The various methods of finding the sound power each come with their own advantages and disadvantages, of which the following table provides an overview.

Acoustic pressure-based methods

Advantages

- different procedural standards for different applications
- simple data recording and sensor technology

Disadvantages

- only supports measurement in the far sound field
- assumes a 0^{th} order spherical emitter
- technically more difficult, since interference noise must be measured in an extra step
- interference noise must be stationary
- the measurement environment affects the results and must be corrected for
- the measurement environment must be measured

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"Direct measurement of intensity"

Advantages

- supports measurement in both near- and far sound field, since the data acquired is phasing between p and v
- external interference has no influence, if it enters from a stationary source during the entire measurement cycle,
- supports variety of wave types
- measurement environment doesn't affect measurement

Disadvantages

- complicated sensor technology and data acquisition
- high precision and broad frequency ranges require different sensors and spacers, and thus multiple measurements

22.2 How to configure the sound power analyzer

Once you have created a new project for the sound power analyzer, you are next prompted to make global settings for the Sound Power Analyzer.

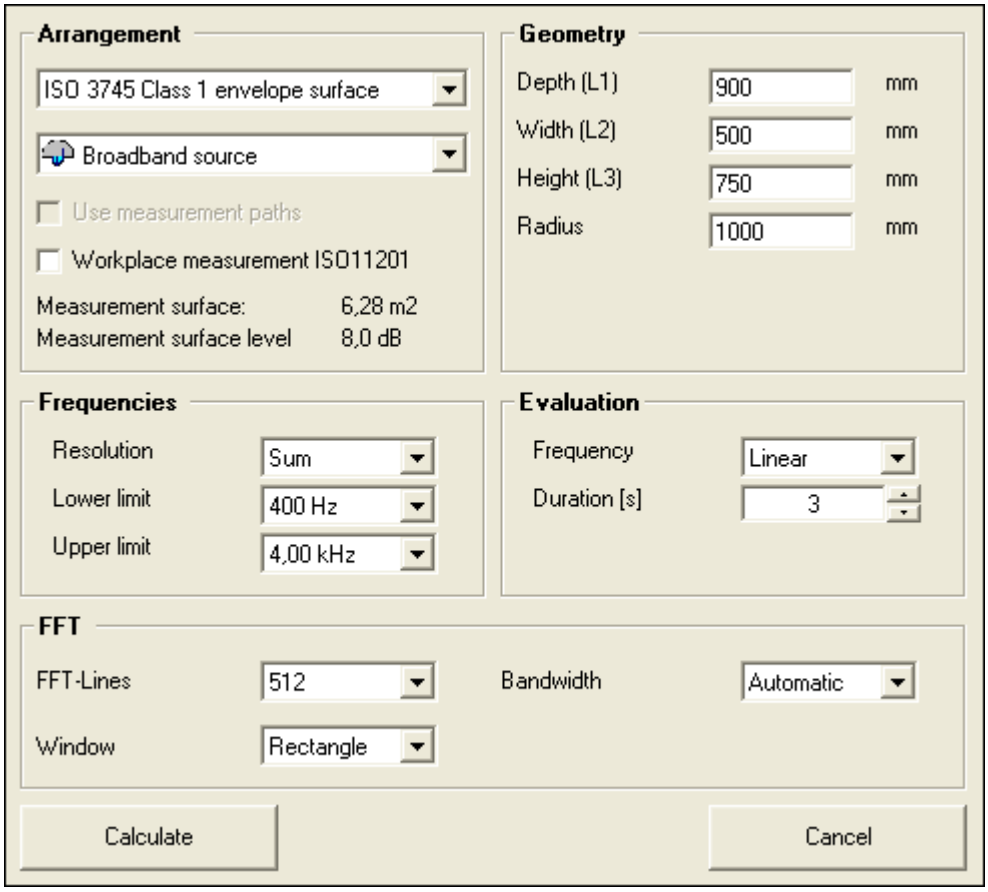

Fig. 115: Global Sound Power Analyzer settings

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There are different options available for determining the sound power:

- ISO 3741 Echo chamber Class 1
- ISO 3743 Echo chamber Class 2
- ISO 3744 Enclosing surface Class 2
- ISO 3745 Enclosing surface Class 1
- ISO 3746 Enclosing surface Class 3
- ISO 11094

and the related method for determining sound power as workplace noise according to

- ISO 11201

This procedure can be carried out parallel to the procedures for determining the sound power.

Select one of these procedures and then chose, as far as possible, an arrangement for your microphones from the list of measurement point configurations.

Then you must define the size of your test object and the distances from the source to the microphones.

This concludes the global geometric definition of the measurement setup.

Set how long to run the measurement (Start-Stop operation or a defined measurement duration).

Also set the frequency range and resolution at which you wish to take measurements:

Resolution:
- 1/3-octaves
- octaves
- sum

Frequency limits:
- lower frequency range limit
- upper frequency range limit

In addition to time-domain data and the (1/3-) octave spectra, you can also have narrow-band spectra computed on the basis of FFT analyses. The configuration references the following parameters:

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- Lines online
  Amount of lines within the spectrum's bandwidth
- Window
  Selection of the window function with which the time-domain data are weighted prior to computing the FFT spectra (more precise information on the selection of window functions is presented in the chapter on the Structure Analyzer)
- Bandwidth
  Select the bandwidth for the FFT spectra. The bandwidth depends on the amount of channels active.

You have the option to set the entries made as default specifications. To do this, select the menu item "Defaults – Adopt values as default" in the dialog. The next time the dialog is started, it will automatically contain the settings you made, saving you the trouble of entering them again.

After making these settings, press the button "Calculate". imc WAVE calculates for you the number of microphones with their positions and the number of calculated quantities required to comply with the procedural standard selected.

After configuration is complete, the following dialog appears on screen.

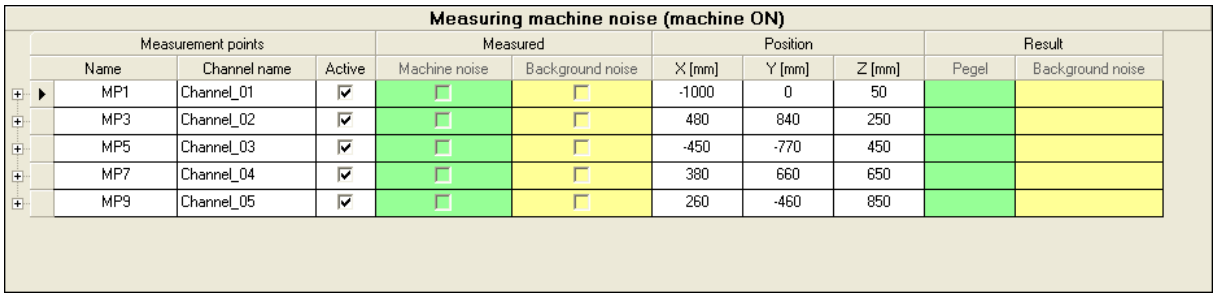

Fig. 116: Configuration dialog for Sound Power Analyzer

In this dialog, an illustration representing the positions of the measurement points is displayed. The positions are either calculated by imc WAVE, or you can enter them directly into the table. There is also a display indicating whether levels of the machine noise and environmental noise have been measured.

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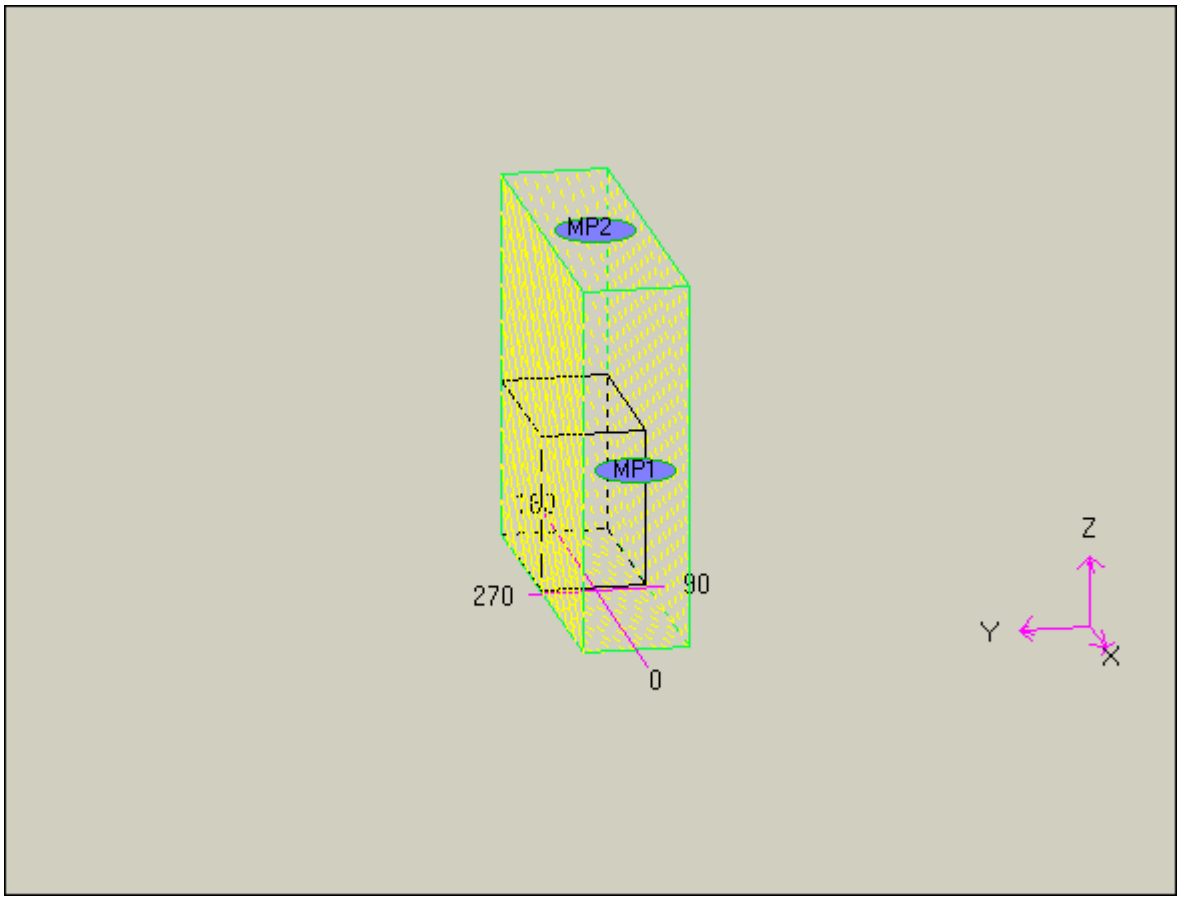

Fig. 117: Positions of microphones relative to reference cube

You can check the microphones' positions in the graphic underneath the table.

It is possible to associate individual input channels with microphone positions. To do this, select from the list of channel names an input channel for each measurement point. Multiple assignments are possible, so that, for instance, 4 microphones can be used to sequentially measure at 12 microphone positions.

Once you have finished assigning channels to microphones, you can set individual channels to active. In this context, it is only possible to assign a physical input channel to a single measurement point. imc WAVE checks the assignment and always sets the last channel assignment you make as active. All assignments made previously are automatically deleted by imc WAVE.
When you have completed the assignment of input channels, you can if you wish save these assignments as defaults. To do this, begin by right-clicking the mouse over the table.

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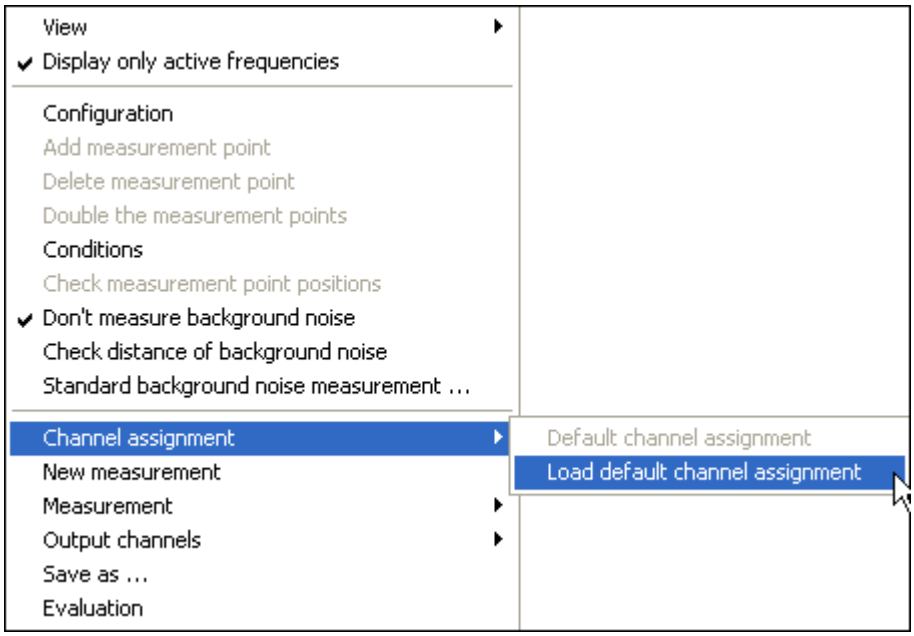

Fig. 118: Setting the default assignment of microphones to input channels

Select the entry "Channel assignment – Default channel assignment". The current assignment of the physical input channels to the microphone positions is then saved automatically. You then have access to this default assignment in every other project; you can load it by selecting the context menu item "Channel assignment – Load default assignment".

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22.3 The contribution of environmental corrections

The various procedures each have different conditions for conducting tests. Some procedures have correction values for environmental conditions such as temperature, air pressure, wind velocity and air humidity, or there are so-called room corrections, which compensate the influence of the measurement space on the sound power measurement.

All these corrections are collected under the menu item "Conditions". The dialog which appears presents the correction values for the procedure you selected.

You can enter the environmental conditions in the upper portion of the dialog.

The table in the dialog's lower portion is used to perform room correction.

Two different procedures for room correction are currently supported:

1. Correction using reference sound source for enclosing surface method
2. Correction using echo time for echo chamber method

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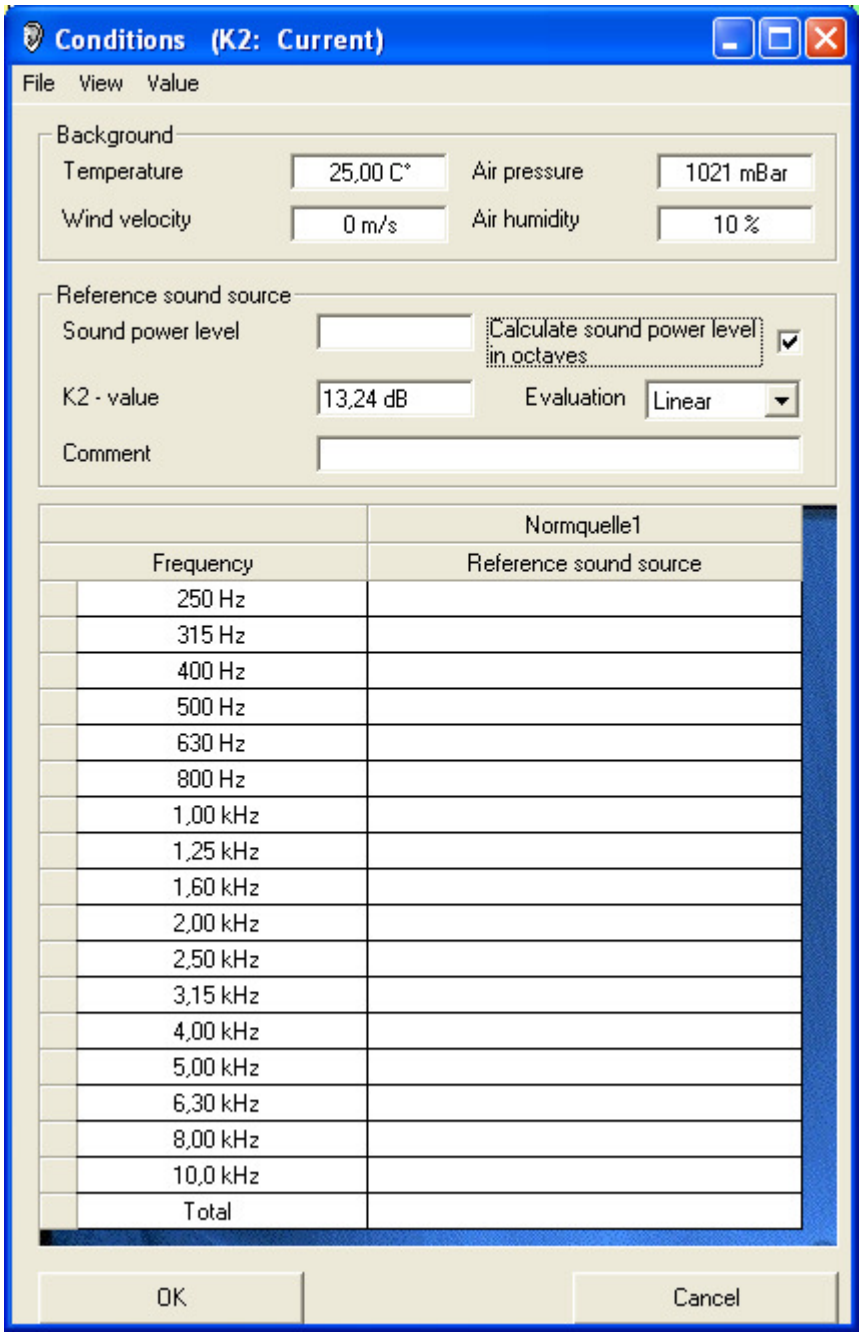

Fig. 119: Dialog for entering correction values

Reference sound source method

The first method conducts a sound power test with the help of a reference sound source, and saves the results. Then the "Conditions" dialog is called and the reference sound source's target values are entered into the table (Reference Source column).
Depending on the frequency resolution set, you must now compute the target values for the (1/3-) octave bands or for the sum level. When calculating the sound power from the sum level, you have the additional

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possibility of calculating the room correction value K2 from 1/3-octave values which you obtained by calibrating to a reference source.

Next, you can use the menu item "Value – Import from measurement" to activate the measurement containing measured values for the reference sound source. After that, activate the menu item "Calculate with reference source" to cause the correction values to be computed.

Echo time method

In this version, the echo time is not determined directly with the sound power analyzer. After calling the Conditions dialog you can enter the echo times into the table, which are then used for room correction in the echo chamber procedure.

All correction values used in calculations are saved under the measurement.

But both the K2 room correction values and the values for the reference source can be fully administered, i.e. you can save, open, delete rename them, se desired. For this purpose the corresponding items are available in the File menu.

You also have the ability to export values in the table to a file or to import them from a file. In this way, you can exchange correction values between different projects.

We are now ready to conduct a first measurement.

22.4 How to perform a measurement with the Sound Power Analyzer

After the measurement has been configured as described in the previous chapter, you must decide whether to measure the machine or environmental noise first. The current setting is indicated above the table. Simply click on the text and the setting is switched automatically.
Before conducting a measurement, the corresponding measurement setup must be made available. Connect the appropriate sensors to the measurement device and connect the measurement device to the computer. For assistance in this, refer to the included imc CRONOS PL user's manual.

Once the necessary connections have been made, you can initialize measurement by pressing the button , and start measurement using the button . If no trigger has been defined, the measurement will start. If a trigger has been defined, data acquisition will only start once the

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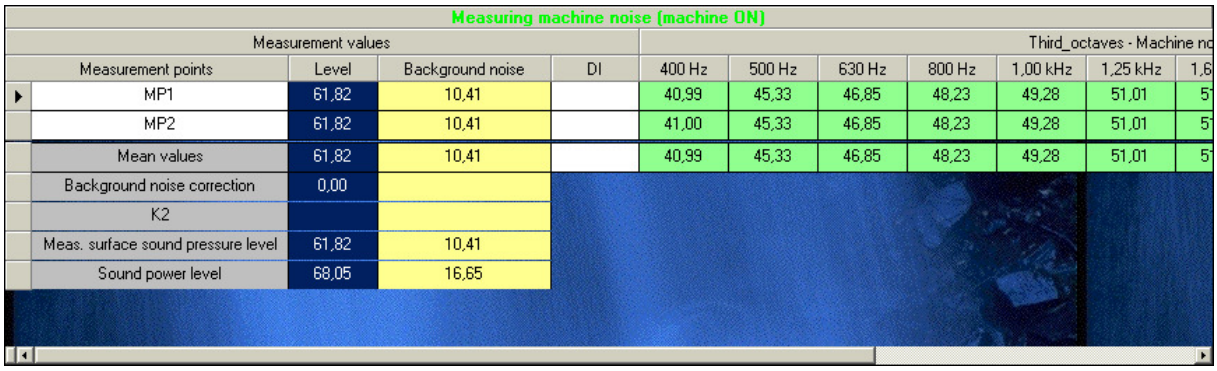
trigger has been released due to the occurrence of the associated conditions. The accumulating data can be viewed in a screen. Toward that end, create a screen which displays the necessary measured data (on this topic, see the chapter on creating curve windows and screens).

Upon the measurement's conclusion, the data can be saved to the disk automatically (on this topic, see the chapter "Data" on the available settings options).

You can switch at any time from display of measurement points to display of results by selecting the menu item "Sound power – Display" and activating the corresponding option.



Measuring machine noise (machine ON)

Measurement values				Third_octaves - Machine no						
Measurement points	Level	Background noise	DI	400 Hz	500 Hz	630 Hz	800 Hz	1,00 kHz	1,25 kHz	1,6
MP1	61,82	10,41		40,99	45,33	46,85	48,23	49,28	51,01	5
MP2	61,82	10,41		41,00	45,33	46,85	48,23	49,28	51,01	5
Mean values	61,82	10,41		40,99	45,33	46,85	48,23	49,28	51,01	5
Background noise correction	0,00									
K2										
Meas. surface sound pressure level	61,82	10,41								
Sound power level	68,05	16,65								

Fig. 120: Display of Sound Power Analyzer results

Once again, you can set up and save curve windows and screens for the measurement. These will allow you to observe the measurement results during a running measurement.

At the end of the measurement, you are prompted to either accept or discard the measured data. If you accept the data, they are entered into the table in accordance with the valid settings.

Following the measurement of the machine noise, you can also carry out the measurement of the background noise. Begin by clicking on the table's header. The respective measurement type selected will be indicated by a text in the header. There is a variety of options for measuring background noise.
For instance, the measurement of background noise can be deactivated. In that case, 0 dB are always recorded for the background noise at each microphone position. The sum level is formed by adding up the 0 dB per microphone position. To obtain this measurement style, open the context menu by right-clicking in the table and select the item "Don't measure background noise".

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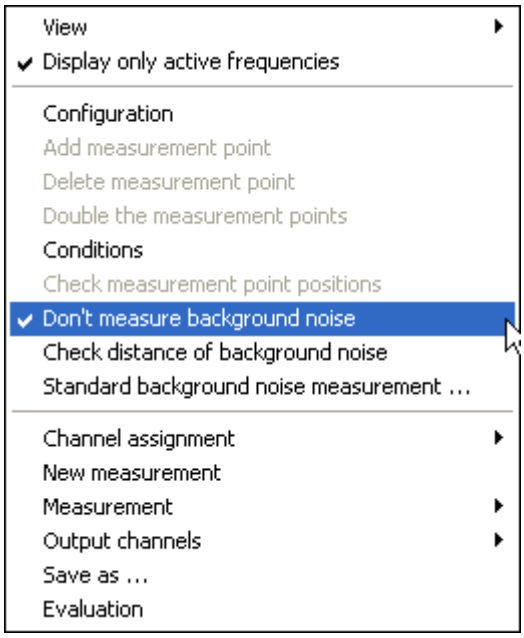

Fig. 121: Configuring measurement of background noise

If you have measured the background noise but don't wish to verify it, you can deactivate the check. To do this, access the menu item "Check distance of background noise" and remove the check-mark in front of this menu item. Then there is no check of the background noise at the end of the measurement. But if you are taking a standards-compliant measurement, be sure to activate the checking again since you would otherwise not receive any notification in case there is too much background noise, and your measurement may not have validity.

If you are working in an environment with stationary background noise, you can measure it once per day, or upon any change, and then assign it to subsequent measurements. In that case, you wouldn't need to be constantly carrying out background noise measurements and you can thus increase the efficiency of your measurement efforts. Simply perform a normal background noise measurement, and then designate it as the default noise measurement. You can later access this default noise as desired.

The columns of values for the environmental noise are shaded yellow; those for the machine noise green. When switching between the display modes, the third-octave or octave values appear in front of correspondingly colored backgrounds.

Next, perform all necessary measurements.

Once all measurements have been performed, the sound power level is automatically calculated and new rows are added to the table of results.

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You can then view the results either as the total sound power or as partial sound powers in the frequency bands if you have selected octaves or 1/3-octaves as the resolution during the configuration. If you selected "Sum" as the resolution, the sound power level is only displayed as a sum value.

This concludes your first measurement of sound power.

To carry out a new measurement, select the menu item "Sound Power – New Measurement". A new data folder is created automatically and the table data are reset.

In this way, you can acquire data on a new test object or repeat the measurement of an already measured test object.

22.5 Extra options

In addition to the settings already discussed, there are other options which can help to make your measurement task easier and more clearly organized.

22.5.1 Changing the number of measurement points

There are various ways to change the number and arrangement of the measurement points, in other words, the microphone positions.

These include:

- Double measurement points
- Add measurement point
- Move measurement point

If you notice during a measurement that the divergence between individual measurement points becomes too great, then you must add new measurement points between the existing ones; this can become necessary, for instance, due to highly directed sound emission from your source. For this purpose, you can add one or more measurement points or even double their number.

To add a measurement point, right-click the mouse over the diagram of measurement points and select the item "Add measurement point" from the context menu which then appears. A new row then is added to the table of measurement points, into which you must enter the new point's coordinates.

To double the number of measurement points, right-click the mouse over the diagram of measurement points and select the item "Double measurement points" from the context menu which then appears. This

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menu item can be activated only once for a single measurement. The number of measurement points in the table then is doubled.

When positioning measurement points, it may occur that no microphone can be placed at a required measurement point, due to some obstruction or obstacle. In such a case, the measurement point's coordinates can be changed in the table; the measurement point "moves". To do this, simply enter in the table the new coordinates in reference to the coordinate system origin. After the change, the table will reflect the new microphone position.

22.5.2 How to change the display of the measurement points

It is possible to change the way the measurement points are displayed in the measurement setup's diagram. You can rotate and zoom in on the test object, thus focusing on the display of particular portions, or change the color of measurement points so as to reflect their states.

The various display options can be selected from the context menu called by right-clicking in the display window.

Rotate
Click on the menu item "Rotate" and select the desired action from the sub-menu which then appears. You can rotate the test object smoothly by moving the mouse over the display area while holding down the left mouse button, or move the test object to a defined position (0°, 90°, 180°, 270° or left, right, rear, bottom or bird's eye view).

Zoom
If you select the menu item "Zoom", you can enlarge the display of the test object by moving the mouse upwards in the display area while holding down its button, or shrink the display by moving the mouse downwards.

Color setting
The various measurement point display elements can have different colors assigned to them.

These include:

- **Measurement box**
  color of box or sphere where the measurement points are located,

- **Object box**
  color of box enclosing the object to be measured,

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- **Hatching**
  color of the hatching representing the sound-reflecting surface below the test object,

- **Measurement points**
  color of measurement points at which microphones are located,

- **Measured points**
  allows you to distinguish between points already measured and points not yet measured by the color.

Select the object whose color you wish to change.

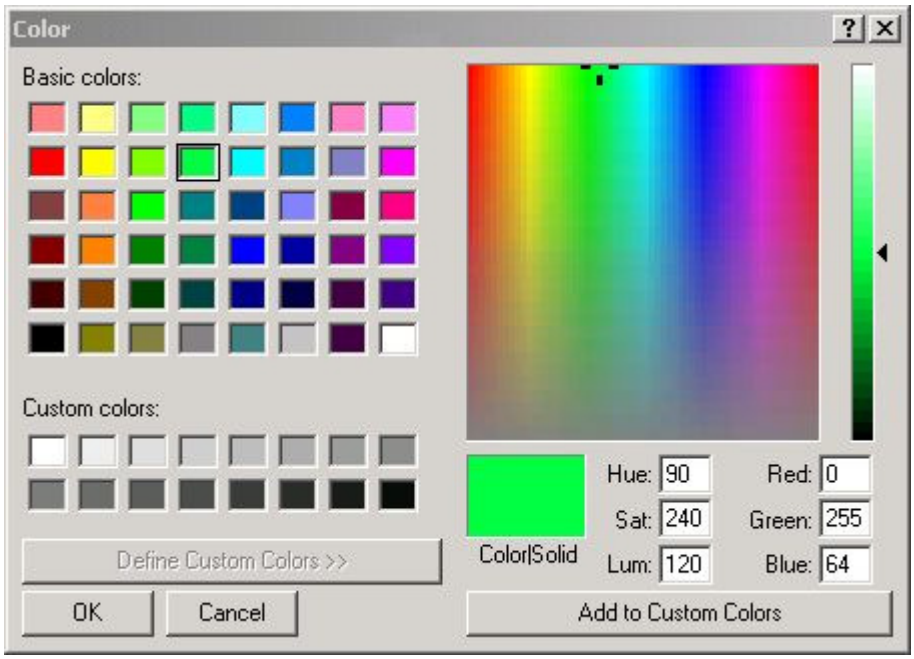

Fig. 122: Dialog for color selection

The dialog for color selection offers various choices of color to assign to objects. On the left side, there is a pool of basic colors and user-defined colors; on the right side the user can define colors by using controls in conjunction with the basic colors.

22.5.3 Subsequent changing of measurement point arrangements

Within a single project you can work with a variety of microphone position arrangements, etc. For each measurement, you can select a microphone arrangement, or in other words, each arrangement of microphones constitutes a new measurement.

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To make a new microphone arrangement, first select the Sound Power Analyzer's menu item "Configuration". A prompt appears for you to choose whether to only view the configuration or actually change it.

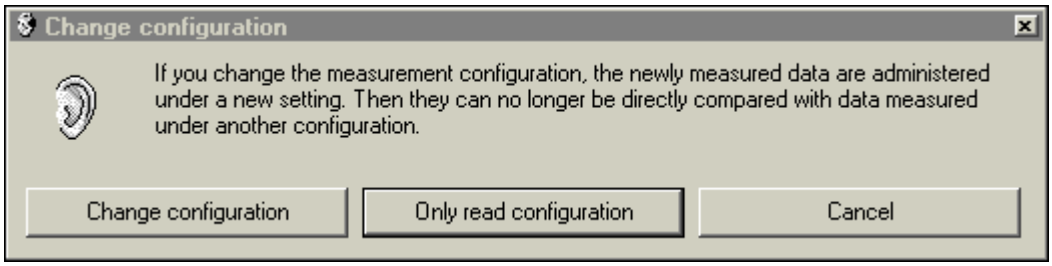
Change configuration
If you change the measurement configuration, the newly measured data are administered under a new setting. Then they can no longer be directly compared with data measured under another configuration.
Change configuration
Only read configuration
Cancel

Fig. 123: Confirmation prompt before changing configuration

Note the different choices:

- View configuration only
  the settings cannot be edited, but only viewed,

- Change configuration
  you can edit the settings, but when you exit the configuration dialog, a new measurement is created in which the new settings apply; the old measurement remains unaffected by the new settings.

22.6 Determining the sound power level of a drill

The following section describes the entire process of determining a drill's sound power level. This procedure serves as an example of a selected standard procedure. Under some circumstances, the procedure may return different results for other standards. Please refer to the description of imc WAVE's Sound Power Analyzer and to the relevant standards for more information.

imc Wave supports a variety of sound power measurements, including:

1. Measurement of the sound power from the total level
2. Measurement of the sound power from the (1/3-) octave bands
3. Measurement of the sound power as a function of an reference quantity

The following is a brief discussion of how to set up a project and of what procedures are necessary for performing each of the three measurement types.

22.6.1 Creating a new project

Before starting with the measurements, we must create a new project. To do this, select in the main menu the item "New Project" in the "File" menu. The following dialog appears on the screen.

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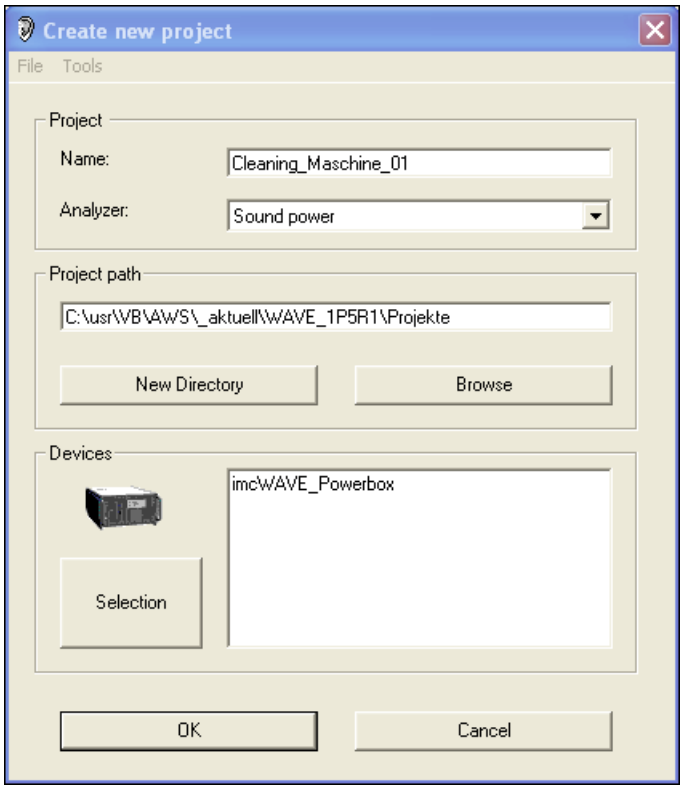

Fig. 124: Creating a new project

First, we select a device for the project. To do this we use the “Select” button. In the dialog which appears next, we cab select a device for the measurement, if any free devices are available.

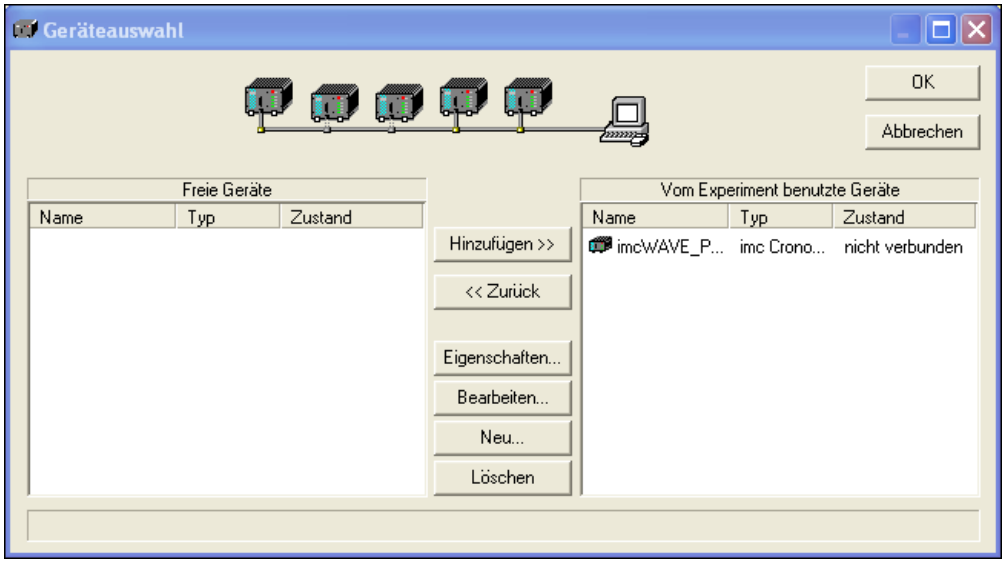

Fig. 125: Selection of free devices for use in the project

If there are no free devices, we click the button “New”.

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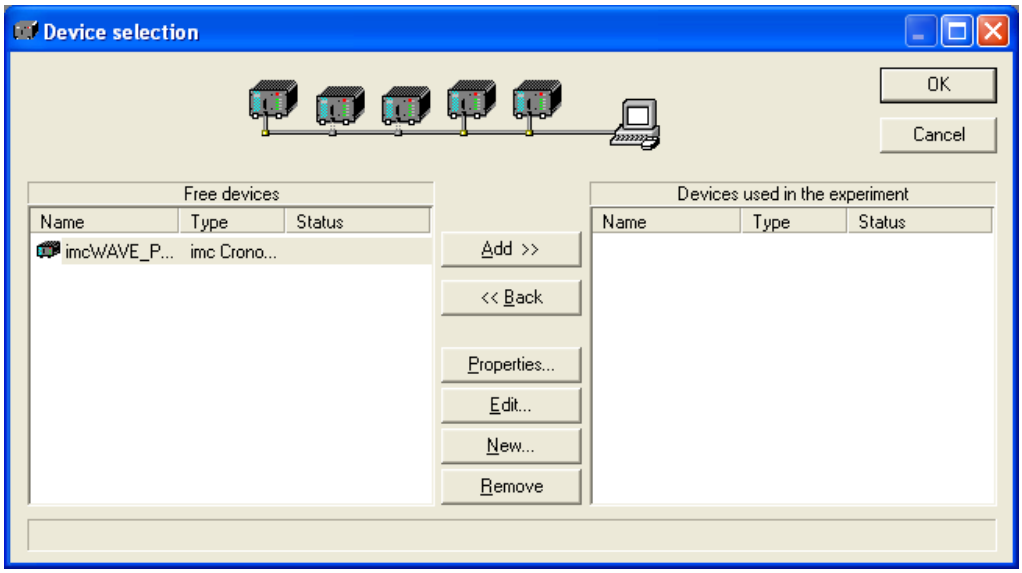

Fig. 126: Network search for new devices

The dialog “Add device interface” now shows all available devices in the network found in the last network search. If the available selection has changed in the meantime, the display can be updated by clicking the button “Network search”. In the Device list, the devices currently found in the entire network, which can be reached from your PC, are indicated. For details, please refer to the documentation on imc Devices or on your measurement device. There you will find more exact information on the network search and on the respective prerequisites for reaching individual devices.

Once you have updated the list, you can select the device from the list to be used for the measurement. When you have selected the device, close the dialog using the OK button. The dialog for selecting the device should then appear as shown below.

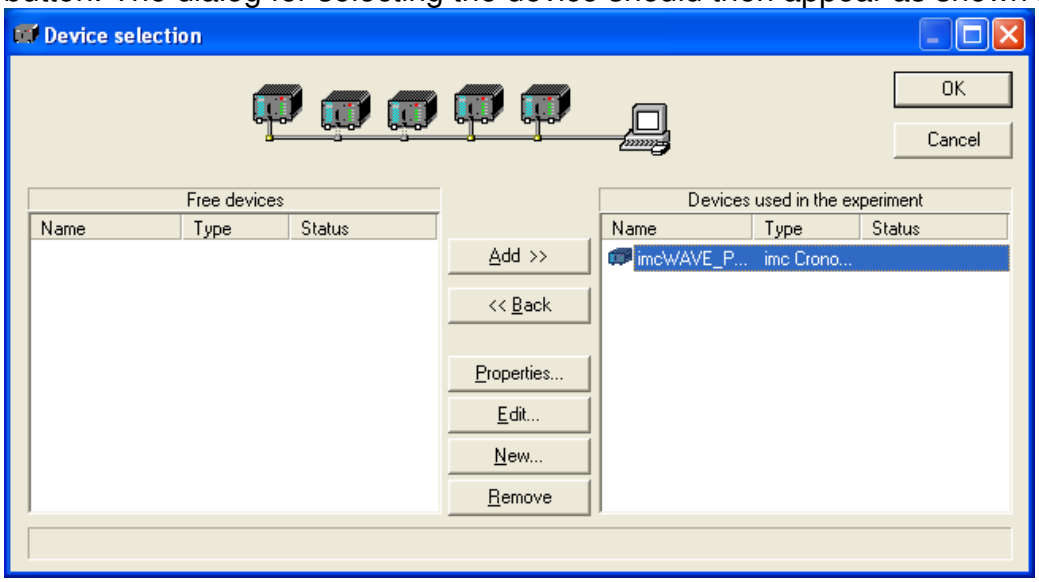

Fig. 127: Device selection dialog for selecting the desired device

After making your choice of device and closing the dialog with the “OK” button, you can specify the project’s name. In our example, the name is

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“Cleaning_Maschine_01”. Then you can select the analyzer. In this concrete example, the analyzer is selected from the pop-down menu “Sound power”.

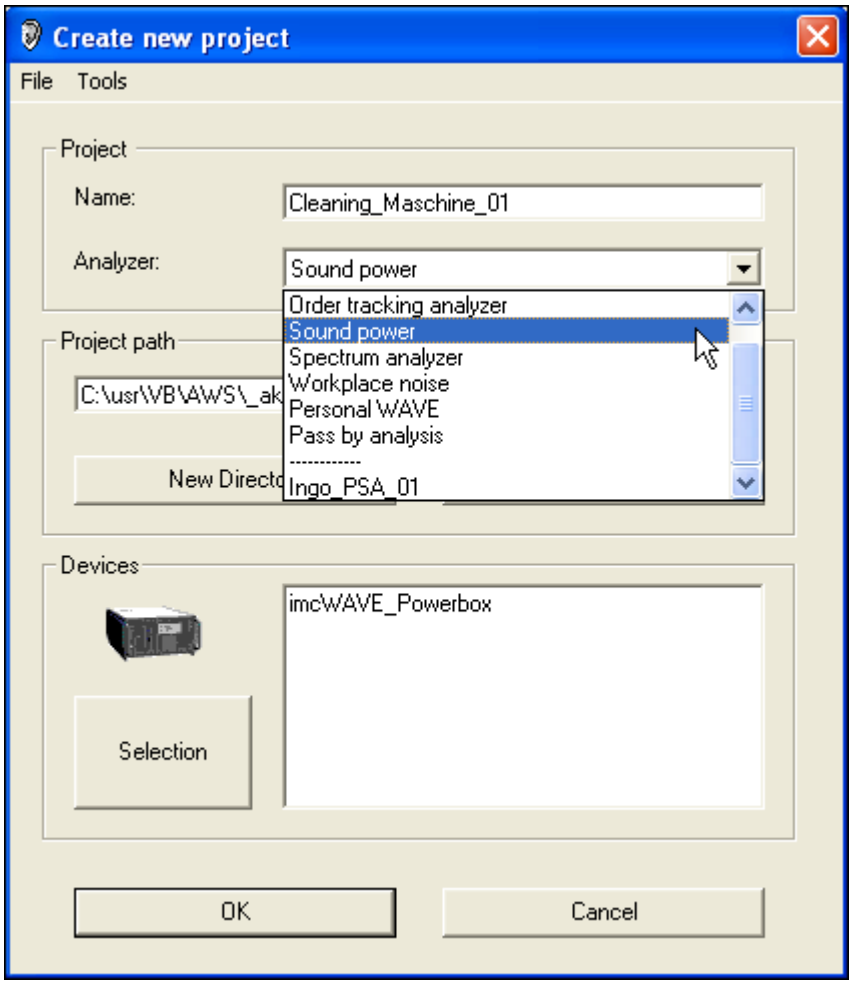

Fig. 128: Device selection dialog for selecting the desired device

Next we can close the dialog for creating a project using the button “OK”. The project is then set up on the PC’s hard drive.

After creating the project and selecting the measurement device, we are prompted to use a dialog to configure the sound power analysis.

22.6.2 Computing the sound power by means of the total level

In this dialog we select the parameters stated above. As the frequency resolution, the sum is specified, i.e. we compute the sound power not in 1/3-octaves or octaves, but rather by means of the total sound pressure level, which means we don’t obtain any information on the partial sound power in each of the various frequency bands.

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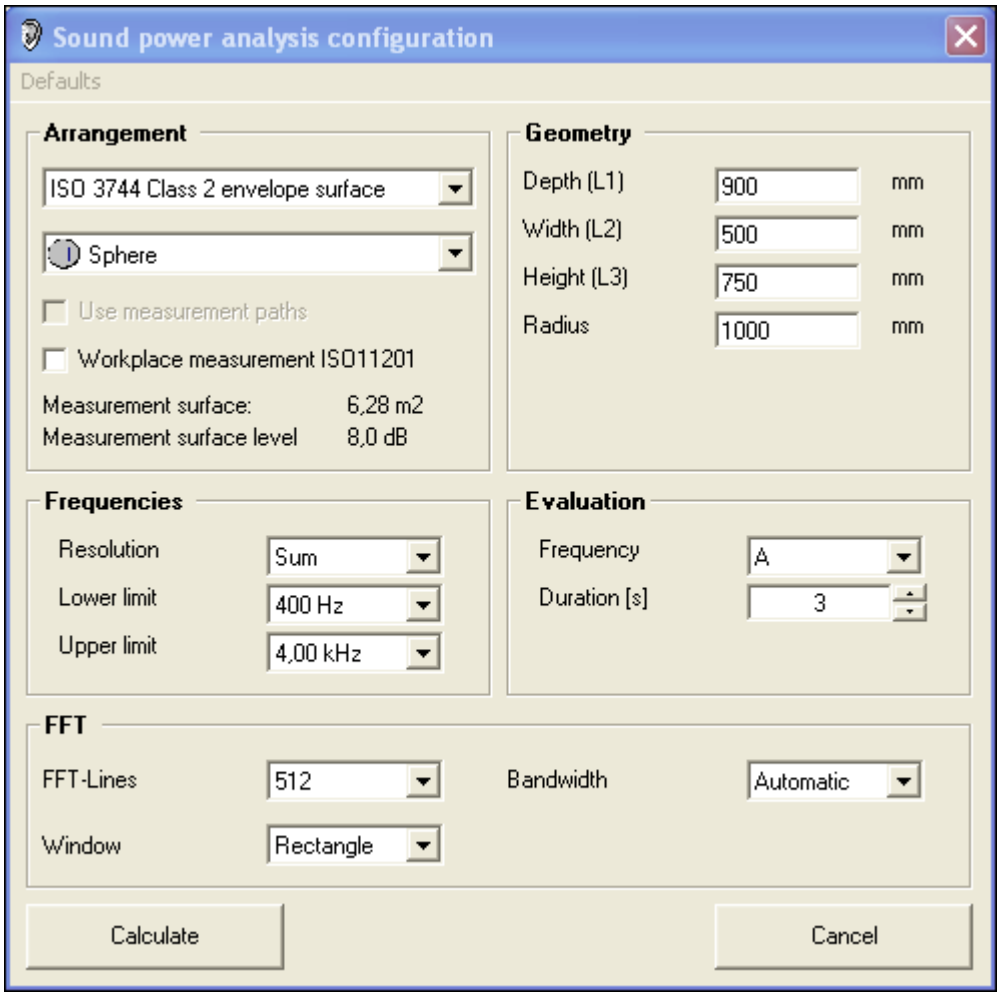

Fig. 129: Device selection dialog for selecting the desired device

We close the configuration dialog by clicking the button “Calculate”, which concludes configuration of the project, and the screen displays imc WAVE’s main dialog with the Sound Power Analyzer in the Project Explorer.

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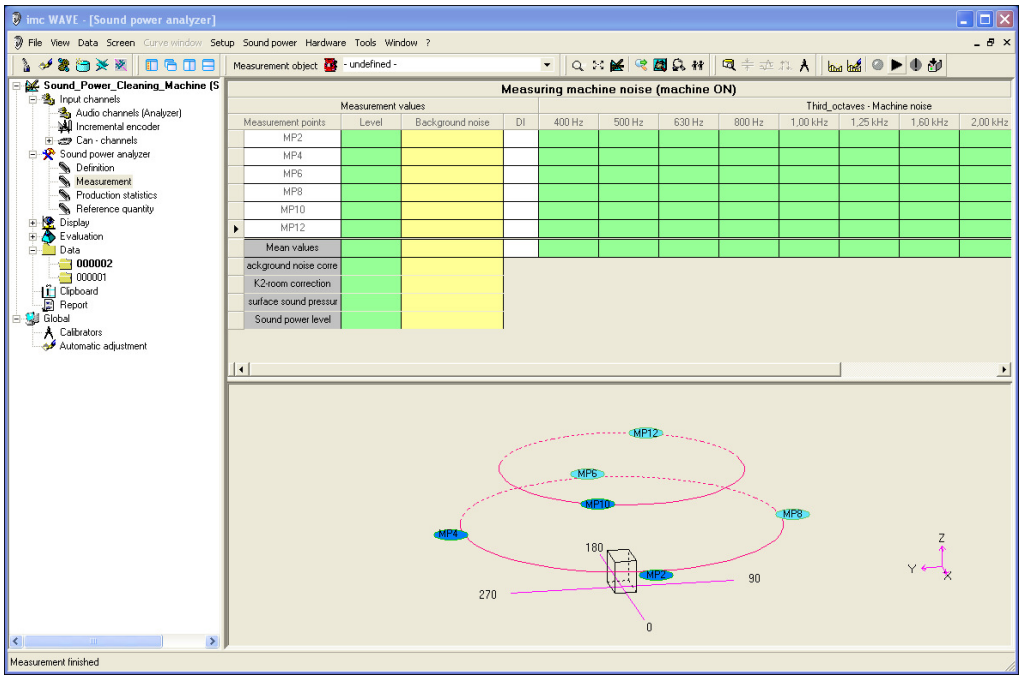

Fig. 130: Main imc WAVE dialog for Sound Power Analyzer project

Before proceeding with configuration of the measurement channels, we activate restoration of the measurement settings; i.e. each time we open a measurement, we also load the settings used for the measurement. To do this, select the item “Options” in the main dialog menu “Settings”.

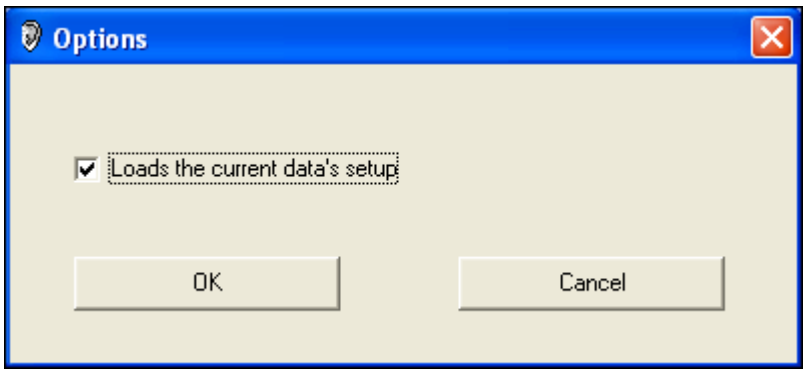

Fig. 131: Loading the settings for the current measurement

Click on the Options button in the dialog. If you don’t activate the Options button, the last setting which you made remains active. But then you can never check with which settings earlier measurements were made.
To apply changes, close the dialog by clicking on the button “OK”.

22.6.2.1 Configuring the input channels with the calibrator and sensor databases

Now we can configure the measurement channels. To do this, we select in the Project Explorer under “Input channels” the entry “Audio channels (Analyzer)”. This entry opens the configuration dialog for the input channels connected with an audio board. We use this board for measurements with microphones, since it allows direct

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connection of both current-fed microphones and microphones with polarization voltage.

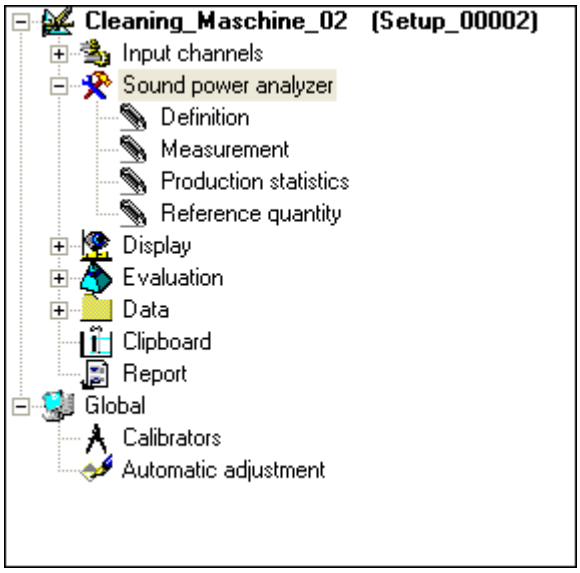
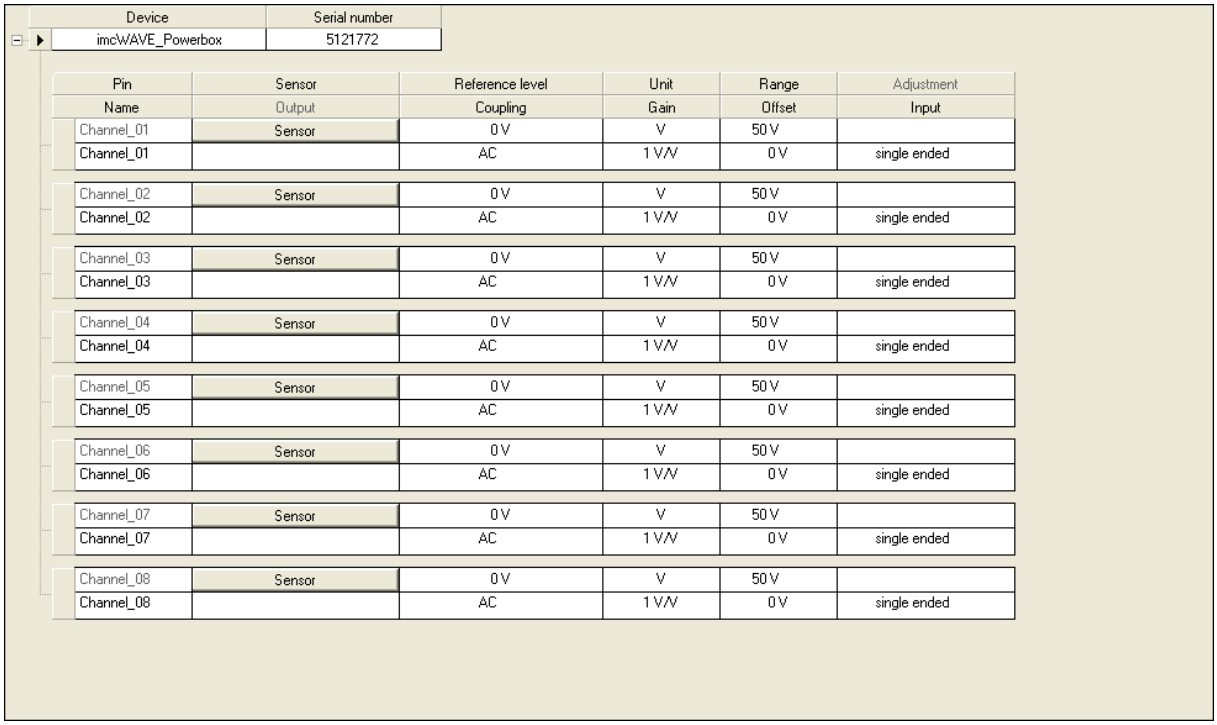


Fig. 132: Loading the settings for the current measurement



Device	Serial number
imcWAVE_Powerbox	5121772

Pin Name	Sensor Output	Reference level Coupling	Unit Gain	Range Offset	Adjustment Input
Channel_01	Sensor	0 V	V	50 V	
Channel_01		AC	1 V/V	0 V	single ended
Channel_02	Sensor	0 V	V	50 V	
Channel_02		AC	1 V/V	0 V	single ended
Channel_03	Sensor	0 V	V	50 V	
Channel_03		AC	1 V/V	0 V	single ended
Channel_04	Sensor	0 V	V	50 V	
Channel_04		AC	1 V/V	0 V	single ended
Channel_05	Sensor	0 V	V	50 V	
Channel_05		AC	1 V/V	0 V	single ended
Channel_06	Sensor	0 V	V	50 V	
Channel_06		AC	1 V/V	0 V	single ended
Channel_07	Sensor	0 V	V	50 V	
Channel_07		AC	1 V/V	0 V	single ended
Channel_08	Sensor	0 V	V	50 V	
Channel_08		AC	1 V/V	0 V	single ended

Fig. 133: Configuration dialog for the audio board channels

In the dialog which then opens, we can make settings for the audio board.
We can enter the settings directly by hand in the table, which is explained in the manual in the appropriate chapters. The method of making settings which is perhaps the most complicated but ultimately the most efficient uses the sensor database. The sensor database administers the various sensors for us, and their data can be transferred to the configuration table with only a few clicks of the mouse. Many sensors, particularly the microphones we are using, possess a calibrator for control purposes and for making preliminary measurements. This calibrator is administered using the calibrator database, which is then linked to the sensor database, so that

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when performing adjustment, the necessary information on the calibrator is available both before and after the measurement.
At the beginning, we set up a calibrator. To do this, double-click on the entry “Calibrators” in the Project Explorer.

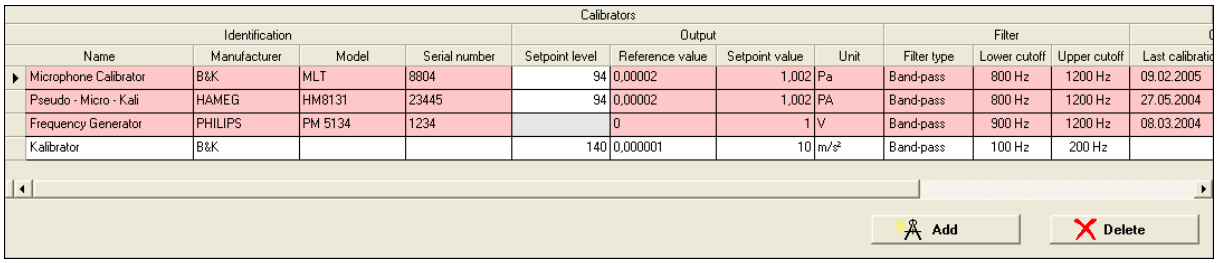

Fig. 134: Setting up a new calibrator

Click on the button “Add” and fill in the entries appropriate for your calibrator into the table. The definitions of the individual entries are state in the appropriate portions of the manual.

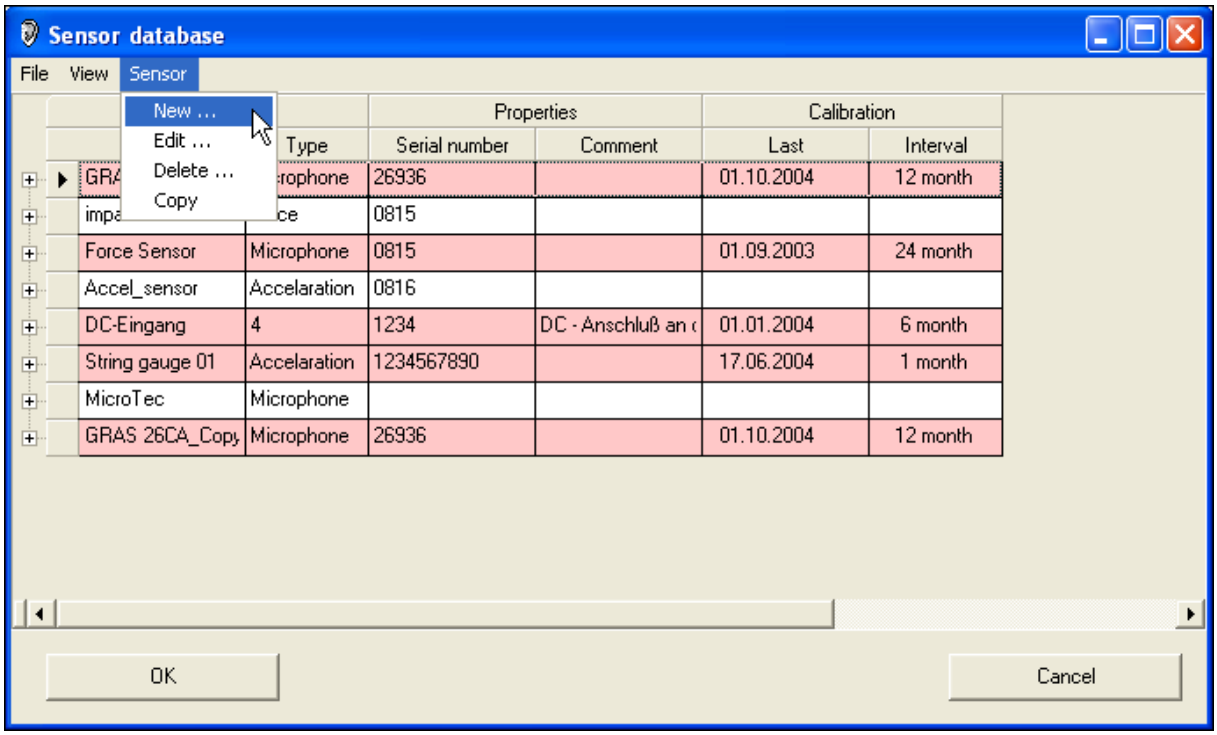

Fig. 135: Setting up a new sensor

Then we go back to the table of the audio board’s input channels.

In the table, we click on the “Sensor”-button in the row which we wish to configure next. If no sensors have been set up yet, an empty list appears. We can set up a sensor by clicking on the entry “New” in the menu “Sensor”.

We use the dialog “Sensor – Definition” to enter the configuration of a new sensor. The definitions of the individual controls are presented in the corresponding locations in the manual. Later in the adjustment procedure, we assign the sensor to the calibrator which was newly set up above. This provides a link between the calibrator

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and sensor databases. All changes to the calibrator then need only be recorded centrally in the calibrator database (e.g. the calibrator's new adjustment value) and are thus available for all sensors.

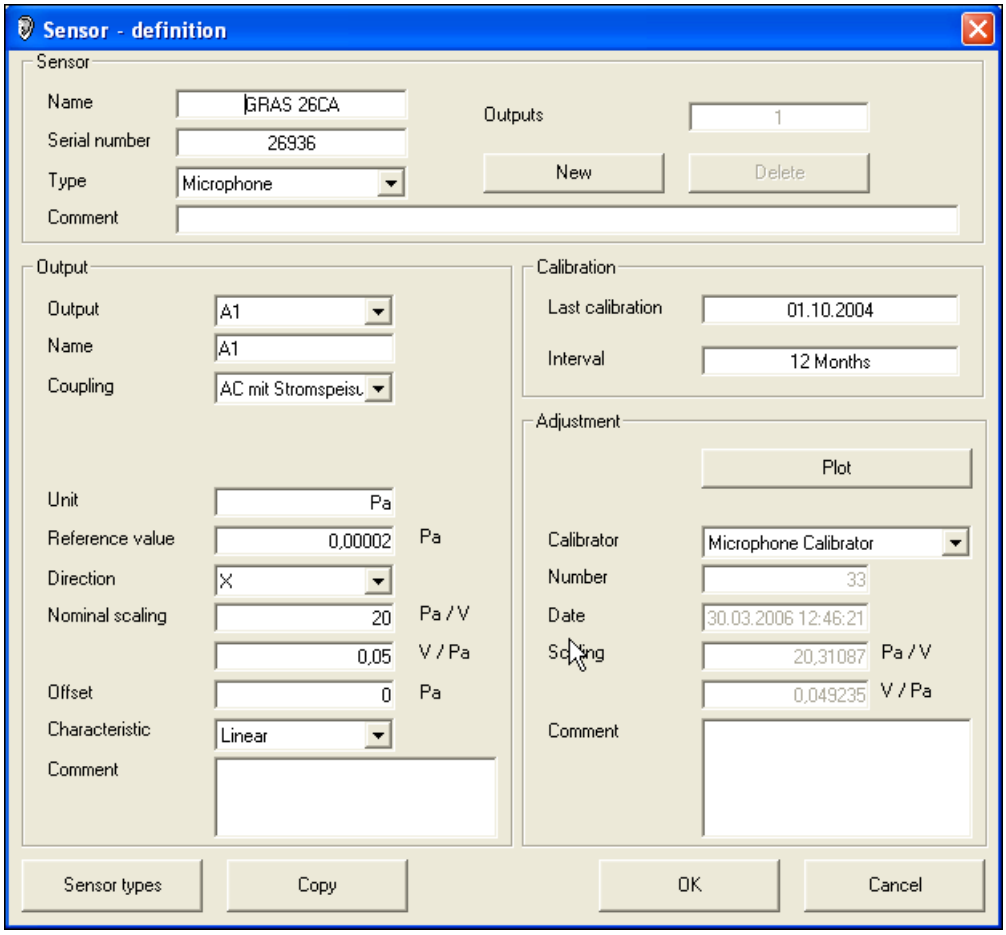

Fig. 136: Setting up a new sensor

After setting up the sensor, we exit the dialog by clicking "OK".

Now the sensor database indicates the newly set up sensor. In order to now assign the sensor to an input channel, we select the sensor (small black arrow at the head of the row) and close the dialog by clicking on "OK".

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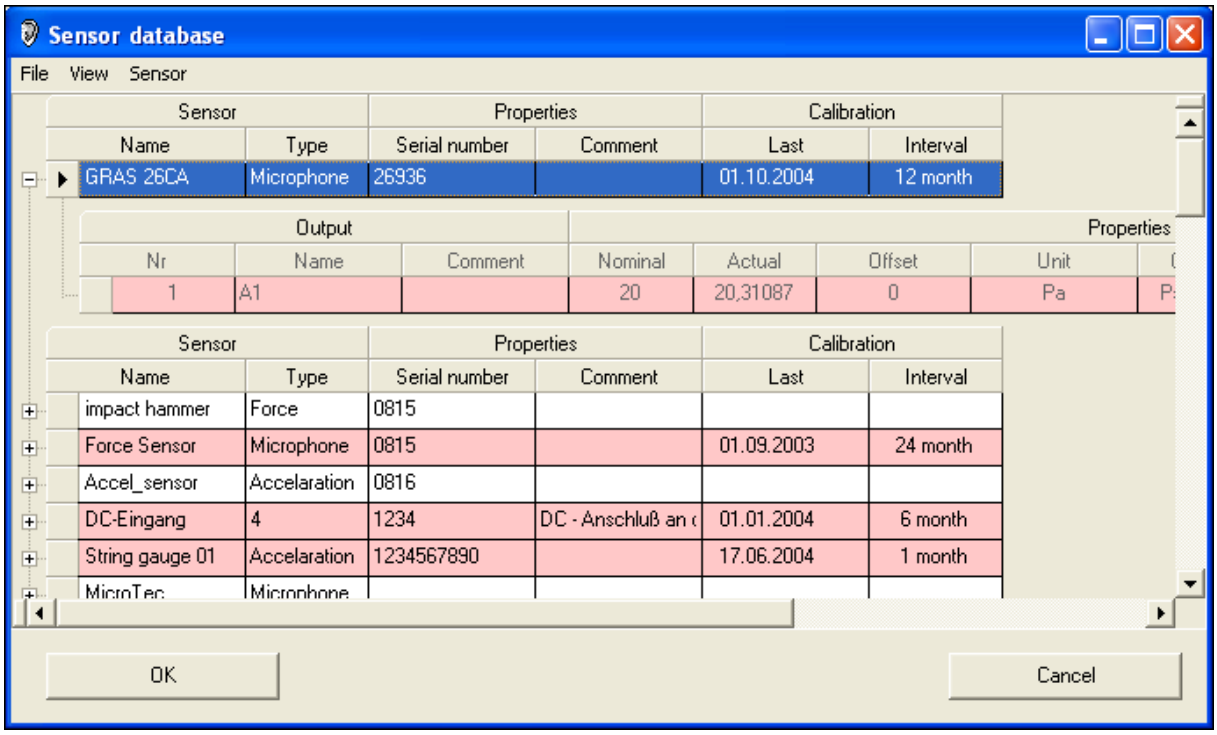

Fig. 137: Newly set up sensor in the sensor database

For instance, if we have assigned the sensor to Channel_01, our dialog will appear as shown below.

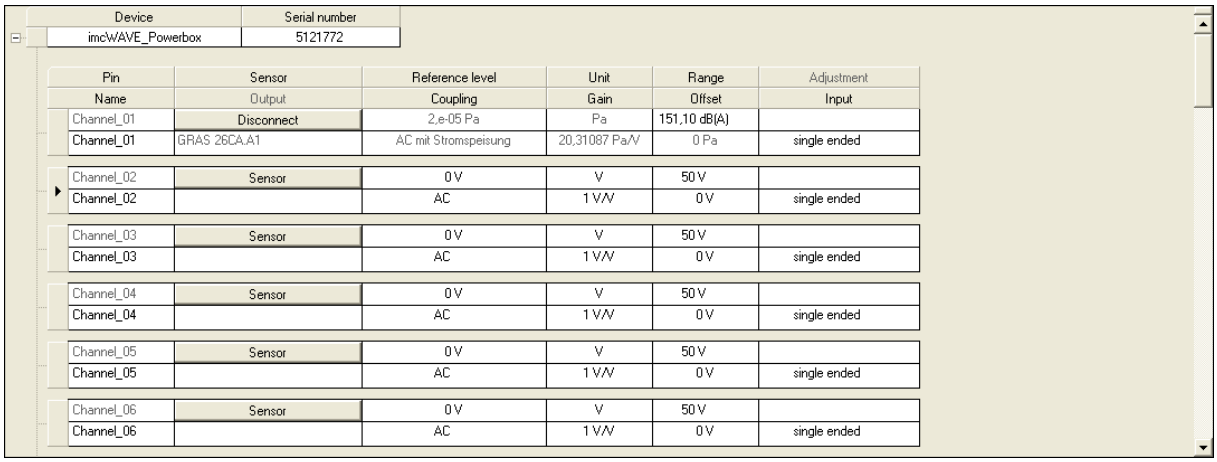

Fig. 138: Input channel Channel_01 with assigned sensor from the sensor database

Now all that is left to do is to select the sensor's input range. To do this, select from the value corresponding to your expectations for the measurement from the "Range"-list.

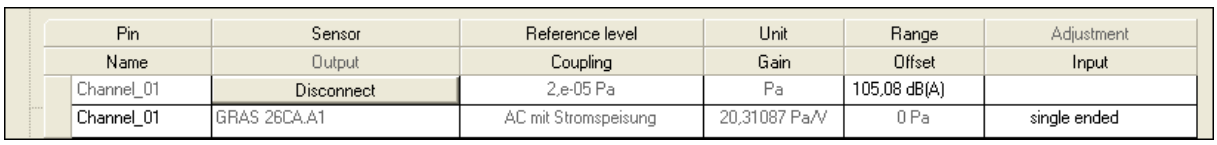

Fig. 139: Input channel Channel_01 with altered input range

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We can then repeat this process for all other sensors and input channels.

If you wish to separate the link between a sensor from the sensor database and from an input channel, just click on the button “Disconnect”. The channel’s settings remain intact, but you can now change all values manually and any changes in the sensor database for the sensor have no effect on the separated input channel.

Once all sensors have been assigned to input channels, the individual channels can be adjusted. To do this, select the item "Adjustment" in the main menu “Tools”.

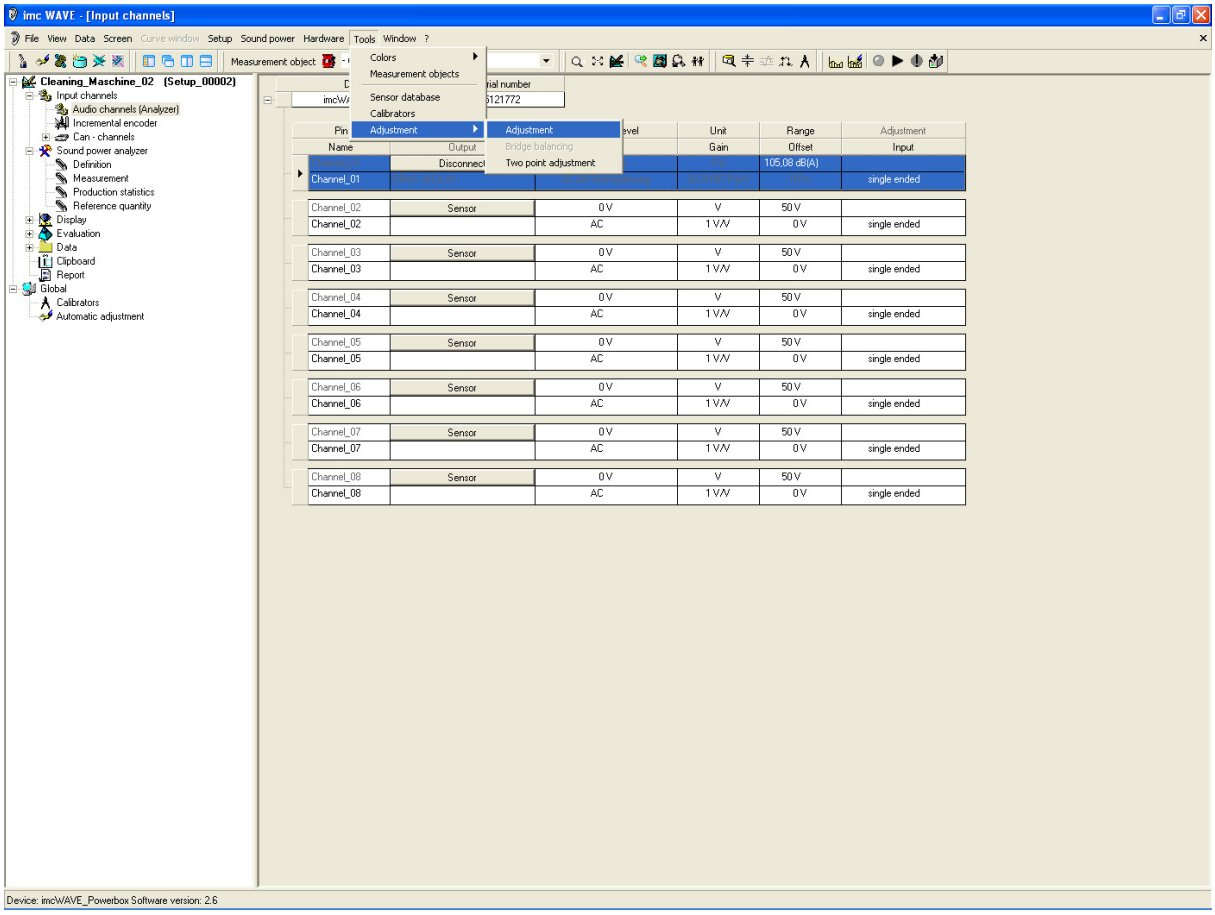

Fig. 140: Calling the adjustment process

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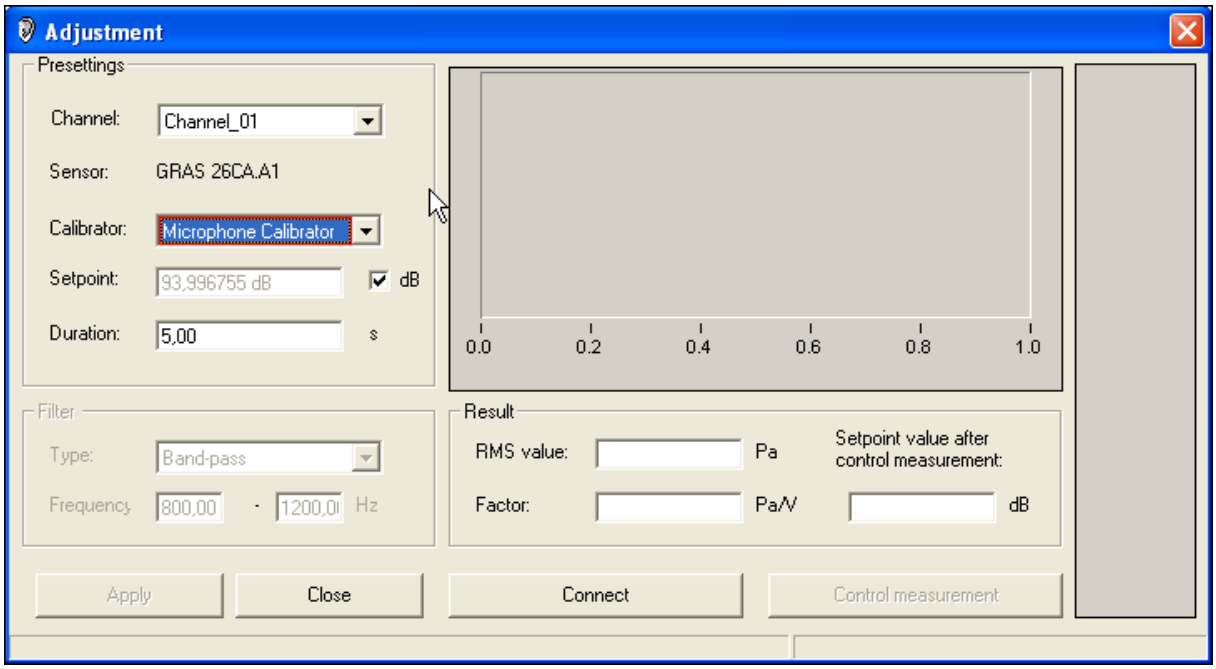

Fig. 141: Calling the adjustment procedure

In the adjustment dialog you can select various channels and the corresponding calibrator data will be imported directly from the calibrator database and displayed. The data appear on the left side of the dialog.

In order to be able to perform adjustment of the desired channel, we must first link the calibrator with the sensor and the sensor with the measurement device's input channel. Then we can prepare the measurement by clicking on the appropriate dialog button.

Afterwards we will start the measurement using the button "Start measurement".

The measurement then runs and the data recorded are displayed in the curve window. At the end of the measurement, the measured voltage's RMS-value is computed and the adjustment factor is calculated on the basis of the calibrator's setpoint value.

If you wish to check this adjustment, click on the button "Control measurement". Then a new measurement is performed applying the previously determined adjustment factor and the result is displayed under "Setpoint value after control measurement". Make certain that your calibrator is still activated, or discrepancies can result.

You can perform the adjustment for the respective channel repeatedly, only when the button "Apply" is clicked are the data assigned to the respective input channel and the input channel's date of last adjustment is reset.

You can then adjust additional channels or close the adjustment dialog.

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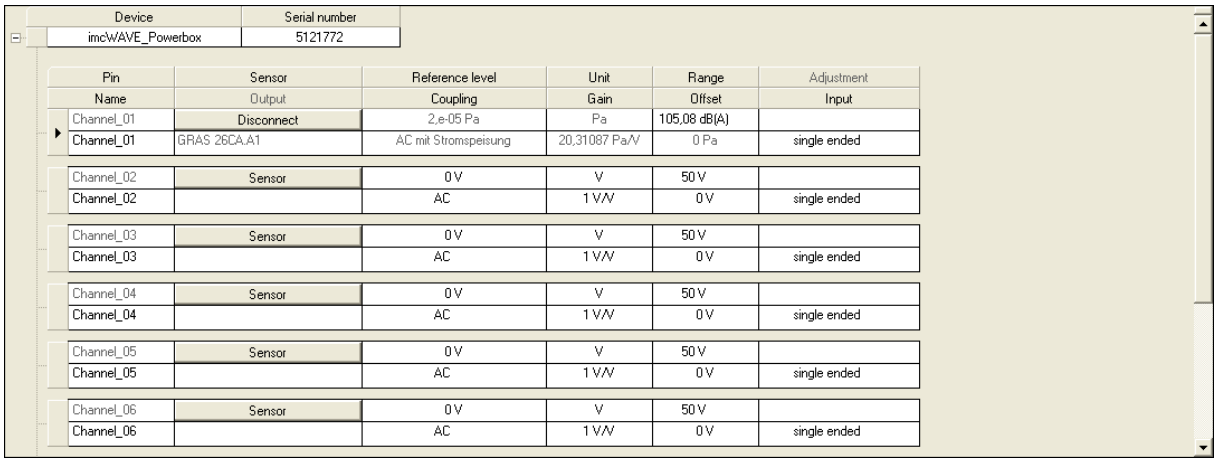

Device	Serial number
imcWAVE_Powerbox	5121772

Pin Name	Sensor Output	Reference level Coupling	Unit Gain	Range Offset	Adjustment Input
Channel_01	Disconnect	2,e-05 Pa	Pa	105,08 dB(A)	
Channel_01	GRAS 26CA.A1	AC mit Stromspeisung	20,31087 Pa/V	0 Pa	single ended
Channel_02	Sensor	0 V	V	50 V	
Channel_02		AC	1 V/V	0 V	single ended
Channel_03	Sensor	0 V	V	50 V	
Channel_03		AC	1 V/V	0 V	single ended
Channel_04	Sensor	0 V	V	50 V	
Channel_04		AC	1 V/V	0 V	single ended
Channel_05	Sensor	0 V	V	50 V	
Channel_05		AC	1 V/V	0 V	single ended
Channel_06	Sensor	0 V	V	50 V	
Channel_06		AC	1 V/V	0 V	single ended

Fig. 142: Input channel Channel_01 after adjustment

22.6.2.2 The analyzer's definitions dialog

Once all input channels have been configured and adjusted, we can proceed to defining the sound power analysis. To do this, click in the Project Explorer on the entry "Definition" under "Sound power analyzer".

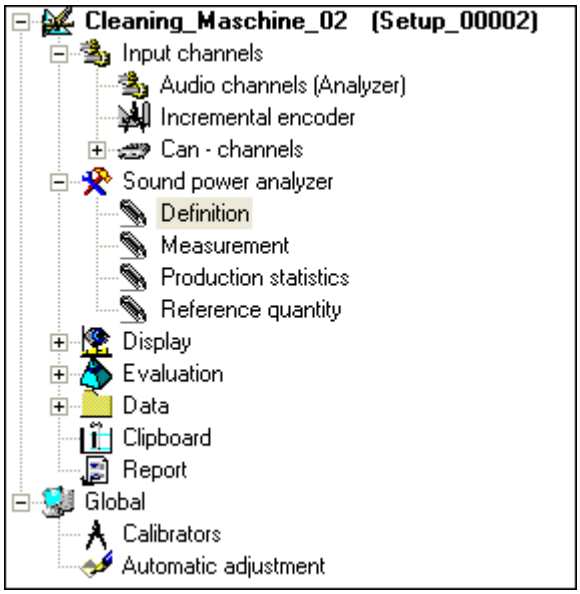

Fig. 143: Calling the analyzer's definitions dialog

Depending on the hardware configuration of your measurement device and on the desired number of microphones, as it results from the measurement standards selected and the spatial arrangement, a certain amount of microphones appear in the definitions dialog.

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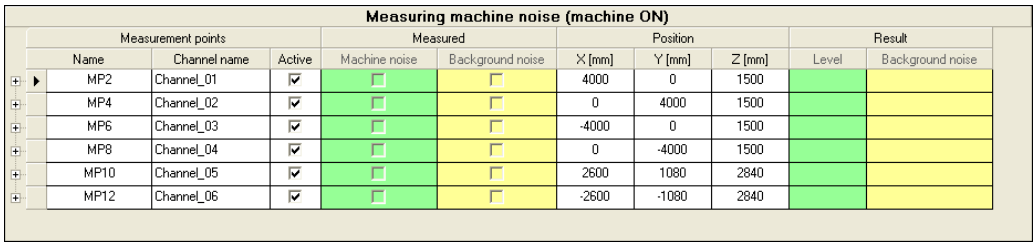


Measuring machine noise (machine ON)

Measurement points			Measured		Position			Result	
Name	Channel name	Active	Machine noise	Background noise	X [mm]	Y [mm]	Z [mm]	Level	Background noise
MP2	Channel_01	☑	☐	☐	4000	0	1500		
MP4	Channel_02	☑	☐	☐	0	4000	1500		
MP6	Channel_03	☑	☐	☐	-4000	0	1500		
MP8	Channel_04	☑	☐	☐	0	-4000	1500		
MP10	Channel_05	☑	☐	☐	2600	1080	2840		
MP12	Channel_06	☑	☐	☐	-2600	-1080	2840		

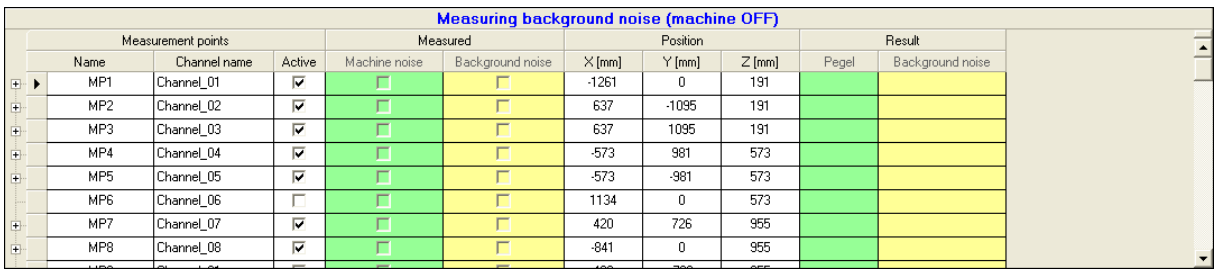
Fig. 144: Definitions dialog for sound power level

In the definitions dialog, the microphones are assigned to the input channels. If you have at least as many input channels as microphone positions, you can determine the sound power with only one measurement. But if you have fewer input channels than microphone positions, you must carry out the measurement in steps. This method conforms to relevant standards if you are measuring a stationary sound. Under “Channel name”, assign the desired channel names to the microphones and activate the corresponding input channels. Next, you must place the microphones at the appropriate positions surrounding your measurement object, in accordance with relevant standards. The necessary coordinates are stated under “Position”. These are meant only as a guide and are not used in the program in any other way.
The green color in the dialog always denotes machine noise and the yellow color denotes background noise.

22.6.2.3 Determining background noise

The relevant standards require a two-stage measurement for determining the sound power. The first measurement determines the background noise while the test object is deactivated, and the second measurement determines the machine noises along with the background noises, which generally cannot be silenced. The standards specify procedural guidelines for dealing with various levels of background noise. These can mean that measurements at insufficient distance from the background noise and machine noise sources may not be valid. imc WAVE automatically checks the distance of the noises for you, computes correction values and ay declare a measurement to be invalid if the distance between the background and machine noises is not sufficient.

In the first step, we wish to determine the background noise. To do this, we must notify the program that we are now measuring background noise. This is done simply by clicking on the title bar of the table in the definitions dialog. Then “Measuring background noise (machine off)” must appear there.



Measuring background noise (machine OFF)

Measurement points			Measured		Position			Result	
Name	Channel name	Active	Machine noise	Background noise	X [mm]	Y [mm]	Z [mm]	Pegel	Background noise
MP1	Channel_01	☑	☐	☐	-1261	0	191		
MP2	Channel_02	☑	☐	☐	637	-1095	191		
MP3	Channel_03	☑	☐	☐	637	1095	191		
MP4	Channel_04	☑	☐	☐	-573	981	573		
MP5	Channel_05	☑	☐	☐	-573	-981	573		
MP6	Channel_06	☐	☐	☐	1134	0	573		
MP7	Channel_07	☑	☐	☐	420	726	955		
MP8	Channel_08	☑	☐	☐	-841	0	955		

Fig. 145: Switching to measurement of background noise in the definitions dialog

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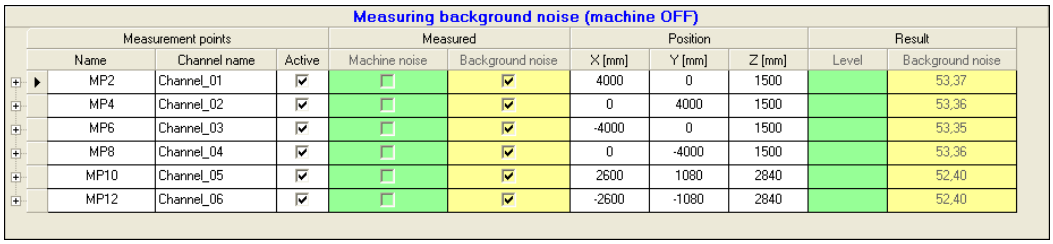
Then we can prepare the measurement and start it. To do this, use the toolbar buttons (Prepare) and (Start).

The measurement runs for the time set. After conclusion of the measurement, the results for the background noise are displayed in the last row. Of course it is also possible to display the measurement results directly as a curve window. On this topic, please refer to the documentation on displaying measured data in a curve window and on combining curve windows in one screen.

Please note that the measured data for the machine noise and for the background noise are saved in different files, so that they can be reconstructed at a later date. However, this means for you that the data must be displayed separately as either background or machine noise. It may be necessary to set up duplicate curve windows or to display twice as many data sets in each curve window.



Measuring background noise (machine OFF)

Measurement points			Measured		Position			Result	
Name	Channel name	Active	Machine noise	Background noise	X [mm]	Y [mm]	Z [mm]	Level	Background noise
MP2	Channel_01	☑	☐	☑	4000	0	1500		53,37
MP4	Channel_02	☑	☐	☑	0	4000	1500		53,36
MP6	Channel_03	☑	☐	☑	-4000	0	1500		53,35
MP8	Channel_04	☑	☐	☑	0	-4000	1500		53,36
MP10	Channel_05	☑	☐	☑	2600	1080	2840		52,40
MP12	Channel_06	☑	☐	☑	-2600	-1080	2840		52,40

Fig. 146: Displaying the background noise in the analyzer's definitions dialog

Since background noise generally doesn't change from one measurement to the next, imc WAVE offers the option of using a background noise measurement as the standard measurement for all subsequent measurements. However, imc WAVE doesn't check for changes in the background noise between measurements, so that the user is responsible to assess whether the same background noise applies. In case of doubt, take measurements of the background noise between successive measurements of the machine noise.
If you are sure, you can define the background noise measurement as the standard measurement for subsequent measurements. Select the item "Background noise – Standard measurement" in the main "Sound power" menu. The following dialog appears on the screen, in which you can select the measurement desired as the standard measurement for background noise.

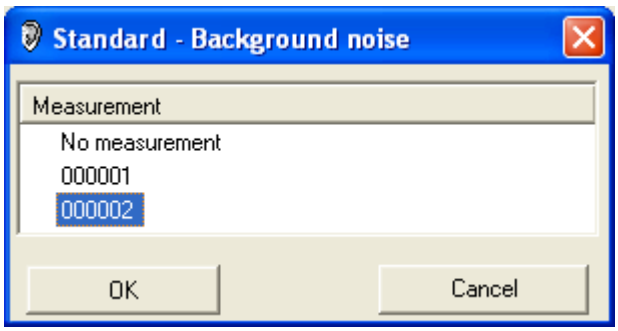


Fig. 147: Selecting the standard measurement for background noise

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Now if the measurement is activated, the background noise of all subsequent measurements is automatically copied from this measurement and joined to the current measurement.

If you wish to cancel this linkage to the standard measurement, select “No measurement” in the selection dialog. This means that in subsequent measurements the background noise must once more be performed manually.

22.6.2.4 Determining room correction with the reference sound source

For analyzing the space or environment in which the sound power measurements are carried out, the relevant standards stipulate a room correction. A procedure for determining a value for this correction is described below. For this purpose, a reference sound source having a sound power level known by previous measurement is introduced into the space. This reference sound source is placed at the measurement object’s intended position.

Switch the measurement type by double-clicking on the table header in the current measurement so that “Measuring machine noise (machine ON)” appears. Now you can activate the reference sound source and start the measurement. At the end of the measurement, the results appear in the definitions dialog in the second to last column.

Measuring machine noise (machine ON)

Measurement points			Measured		Position			Result	
Name	Channel name	Active	Machine noise	Background noise	X [mm]	Y [mm]	Z [mm]	Level	Background noise
MP2	Channel_01	☑	☑	☑	4000	0	1500	74,42	53,37
MP4	Channel_02	☑	☑	☑	0	4000	1500	74,18	53,36
MP6	Channel_03	☑	☑	☑	-4000	0	1500	74,44	53,35
MP8	Channel_04	☑	☑	☑	0	-4000	1500	74,15	53,36
MP10	Channel_05	☑	☑	☑	2600	1080	2840	74,36	52,40
MP12	Channel_06	☑	☑	☑	-2600	-1080	2840	74,47	52,40

Fig. 148: Measurement of the room correction

Upon conclusion of the measurement, the following message is posted.

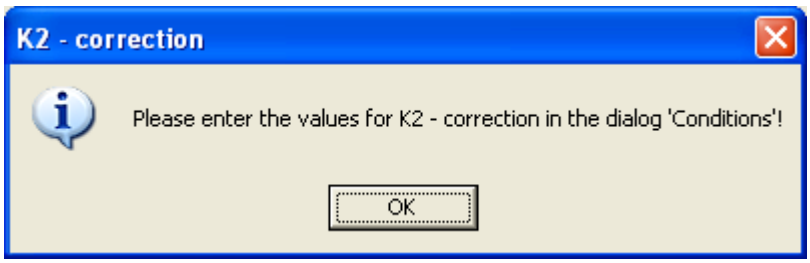

Fig. 149: Error message: K2 room correction not available.

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The program has determined that the room correction for the current measurement are not available. Of course we cannot have these yet, since we are in the process of determining them. So, we ignore the message and click on “OK” to exit it.

Now we switch the dialog displayed from the definitions dialog to the measurement dialog. To do this, select the entry “Measurement” in the Project Explorer under “Sound power analyzer”.

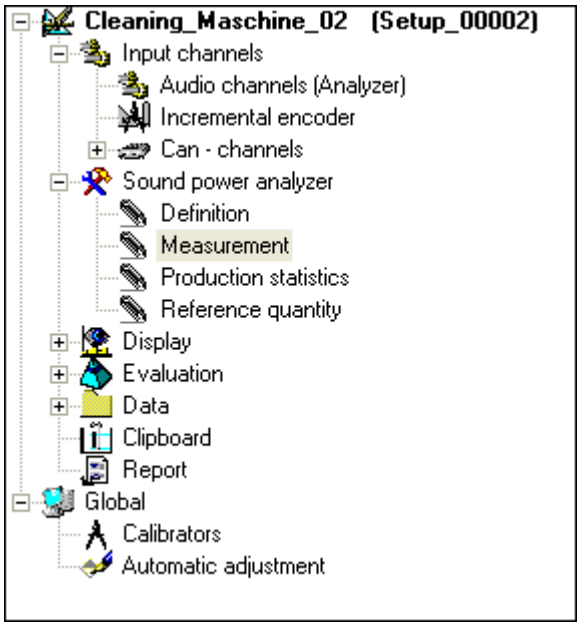
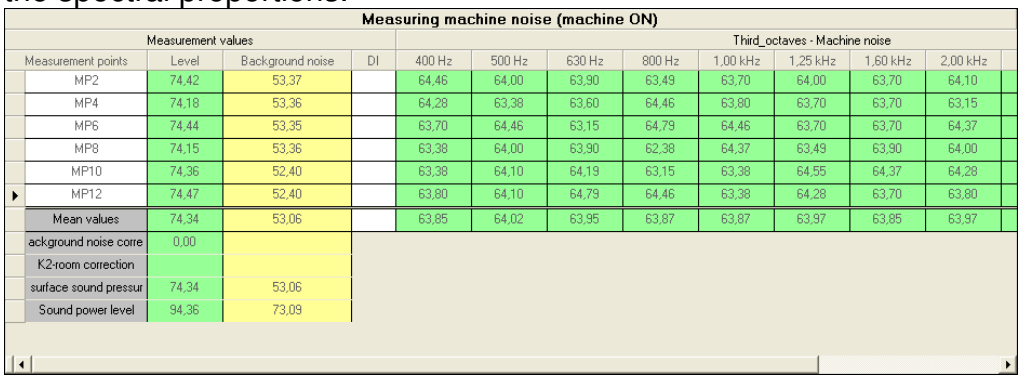


Fig. 150: Switching to the sound power analyzer’s measurement dialog

In this dialog, all measurements are displayed in detail with intermediate results and the spectral proportions.



Measuring machine noise (machine ON)

	Measurement values			Third_octaves - Machine noise							
Measurement points	Level	Background noise	DI	400 Hz	500 Hz	630 Hz	800 Hz	1,00 kHz	1,25 kHz	1,60 kHz	2,00 kHz
MP2	74,42	53,37		64,46	64,00	63,90	63,49	63,70	64,00	63,70	64,10
MP4	74,18	53,36		64,28	63,38	63,60	64,46	63,80	63,70	63,70	63,15
MP6	74,44	53,35		63,70	64,46	63,15	64,79	64,46	63,70	63,70	64,37
MP8	74,15	53,36		63,38	64,00	63,90	62,38	64,37	63,49	63,90	64,00
MP10	74,36	52,40		63,38	64,10	64,19	63,15	63,38	64,55	64,37	64,28
MP12	74,47	52,40		63,80	64,10	64,79	64,46	63,38	64,28	63,70	63,80
Mean values	74,34	53,06		63,85	64,02	63,95	63,87	63,87	63,97	63,85	63,97
ackground noise corre	0,00										
K2-room correction											
surface sound pressur	74,34	53,06									
Sound power level	94,36	73,09									

Fig. 151: The sound power analyzer’s measurement dialog

We see two empty lines below the table, where the values for the background noise and for the K2-correction (room correction) are missing. The background noise correction is not available, since the background noises are almost 20 dB below the machine noise and therefore no correction is necessary. But we now need to determine the missing value for the room correction.
To do this, we call the dialog “Conditions”. This can be done either using the analyzer’s toolbar’s button , or by selecting the item “Conditions” in the “Sound power” menu.

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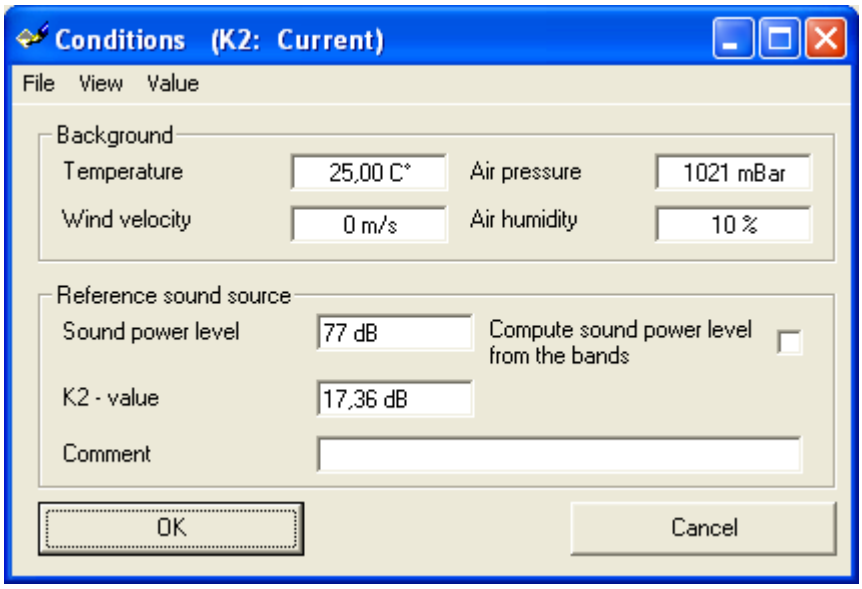

Fig. 152: The sound power analyzer's Conditions dialog

The specified values for the temperature, air pressure, wind velocity and humidity must be entered manually. Procedures of higher precision classes require these values, since corrections are sometimes performed when there are deviations from standard values. In general, it is always advisable to record these values for documentation purposes, since they can later be printed out in reports quite easily.

Now we must notify the program of how great the reference sound source's sound power is, as it was determined by a calibration laboratory. There are two ways to do this:

1. Specify the sound power level as an aggregate value
2. Specify the sound power level in (1/3-) octave bands

22.6.2.4.1 Specifying the sound power level as an aggregate value

If the sound power level is specified as an aggregate value, the check box "Compute sound power level from the bands" must be deactivated. The dialog "Conditions" should appear as shown above.

You simply enter the setpoint value for the reference source's sound power in the input box "Sound power level". In our example, the value 60 dB has been entered. Then we need to have the K2-value computed, which we do by selecting the item "Calculate with reference source" in the "Value" dialog. Now imc WAVE will use the current measurement compute the correction values for the aggregate sound pressure level, so that ultimately the sound power matches the value we specified. The correction value K2 is entered in the corresponding input box. Now we can exit the dialog, since we have determined the necessary room correction.

22.6.2.4.2 Specifying the sound power level in (1/3-) octave bands

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The sound power level can also be specified in terms of (1/3-) octave bands. This manner of making the specification requires a different procedure for determining the room correction.
When we open the dialog “Conditions”, the check box Compute sound power level from the bands” must be activated.

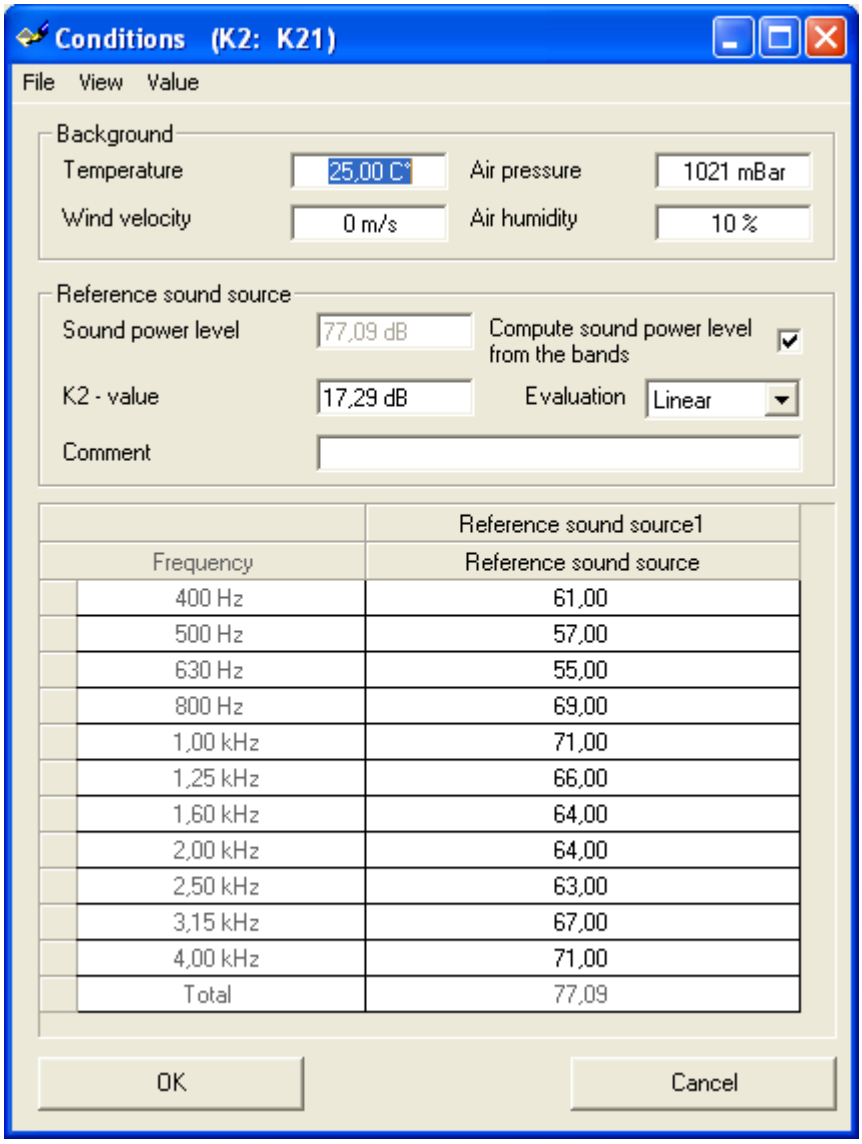

Fig. 153: The sound power analyzer’s dialog Conditions, with calculation of the reference source from (1/3-) octave bands

We can now enter the reference source’s sound power value for each 1/3-octave band in the dialog. imc WAVE then computes from them the corresponding aggregate correction value when we select the item “Calculate with reference source” in the dialog’s “Value” menu. The correction value is then displayed again in the input box “K2-value”.

Next we exit the dialog by clicking on “OK”. imc WAVE re-calculates the sound power for the current measurement, this time using the K2-value which was determined. Since we just recently computed the K2-correction for the reference sound source,

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then the results of the current measurement must definitely be the sound power level of the reference source, otherwise we have made a mistaken entry.

Measuring machine noise (machine ON)

Measurement values				Third_octaves - Machine noise							
Measurement points	Level	Background noise	DI	400 Hz	500 Hz	630 Hz	800 Hz	1,00 kHz	1,25 kHz	1,60 kHz	2,00 kHz
MP2	62,95	30,26		41,27	42,21	45,87	47,34	54,45	53,27	46,70	49,81
MP4	68,78	29,79		41,62	44,32	46,65	49,81	58,42	56,29	56,31	54,75
MP6	64,54	29,71		35,41	38,12	39,70	39,95	53,37	52,71	51,09	55,64
MP8	65,23	30,02		42,13	42,92	45,49	47,09	54,56	51,91	48,65	54,85
MP10	65,65	30,12		37,63	39,94	41,99	43,36	55,89	53,98	54,30	57,35
MP12	68,47	31,44		41,52	43,13	47,93	50,45	54,73	55,70	56,80	60,23
Mean values	66,44	30,26		40,53	42,23	45,39	47,58	55,57	54,27	53,76	56,47
K1-background noise correctior	0,00										
K2-room correction	9,44	9,44									
eas. surface sound pressure lev	57,00	20,82									
Sound power level	77,02	40,85									

Fig. 154: Results of the sound power measurement for the reference sound source

This completes the measurements needed for determining the room correction and the background noise. Therefore the reference source can be removed and the actually intended measurement object positioned for measurement of its sound power.

22.6.2.5 Finding the measurement object's sound power

In order to be able to determine the measurement object's sound power, we must first set up a new measurement. To do this, we select in the main "Sound power" menu the item "New measurement" or the corresponding button in the analyzer's toolbar.

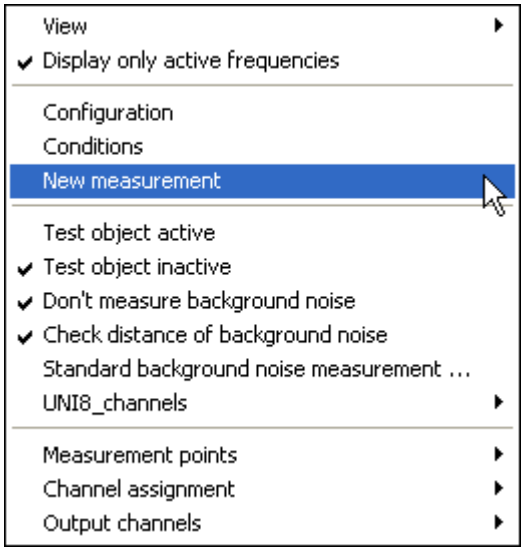

Fig. 155: Setting up a new measurement

Taking a look at the table with the measured values under "Measurements", we see the K2-values already entered. The measured background noise values are only applied and entered into the table once the machine noise is measured.

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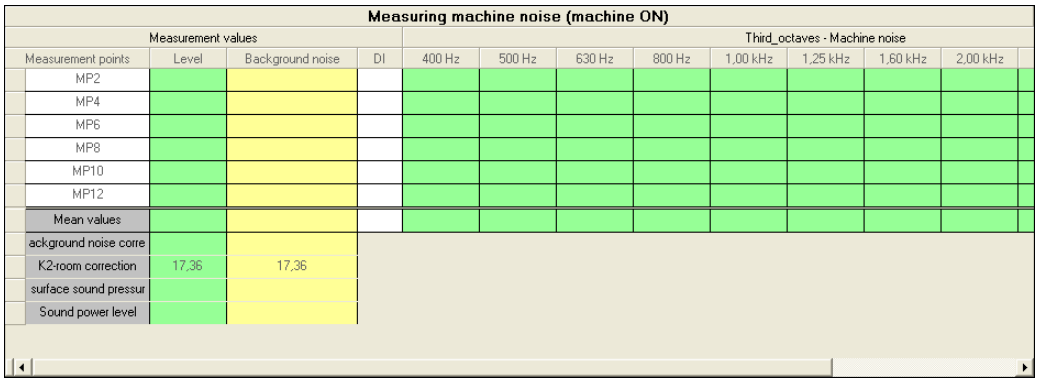

Measuring machine noise (machine ON)

Measurement values				Third_octaves - Machine noise							
Measurement points	Level	Background noise	DI	400 Hz	500 Hz	630 Hz	800 Hz	1,00 kHz	1,25 kHz	1,60 kHz	2,00 kHz
MP2											
MP4											
MP6											
MP8											
MP10											
MP12											
Mean values											
ackground noise corre											
K2-room correction	17,36	17,36									
surface sound pressur											
Sound power level											

Fig. 156: Table for the new measurement with the specified K2-value

Now we activate measurement of the machine noise, unless this has already been done as part of the last measurement, and re-start the measurement once the measurement object has been activated. After conclusion of the measurement, the results for the machine noise are entered in the table.

Measuring machine noise (machine ON)

Measurement values				Third_octaves - Machine noise							
Measurement points	Level	Background noise	DI	400 Hz	500 Hz	630 Hz	800 Hz	1,00 kHz	1,25 kHz	1,60 kHz	2,00 kHz
MP2	68,11	53,17		57,47	57,88	58,35	56,89	57,58	58,26	56,63	57,78
MP4	68,02	53,17		56,89	58,17	57,58	57,13	57,88	57,36	57,88	57,36
MP6	68,25	53,17		57,78	58,17	58,08	57,78	57,58	58,08	58,17	57,13
MP8	68,38	53,17		57,58	58,26	58,35	57,58	57,68	58,08	57,98	57,98
MP10	68,23	51,95		57,88	58,44	57,98	56,89	58,44	58,08	57,36	57,78
MP12	68,17	51,95		57,58	58,08	57,88	57,47	57,98	57,58	57,36	56,76
Mean values	68,20	52,80		57,54	58,17	58,05	57,30	57,87	57,92	57,59	57,49
ackground noise corre	0,00										
K2-room correction	17,36	17,36									
surface sound pressur	50,84	35,44									
Sound power level	70,86	55,46									

Fig. 157: Table for the new measurement with the measured values for the machine noise and the background noise from the standard measurement

The sound power level, with the computed correction values, is indicated in the table's last row. This is the result of the machine noise measurement using the various microphone positions.

22.6.3 Calculating sound power using (1/3-) octave bands

The entire calculation of the measurement object's sound power till now has been performed based on the aggregate sound pressure level. imc WAVE also supports calculation of the sound power by means of the (1/3-) octave bands. With this method, the various corrections are carried out in the (1/3-) octave bands and we thus obtain conclusions about the sound power within the individual frequency bands, which can be very interesting for evaluating modifications of individual machine parts. In the following section, computation of sound power within the (1/3-) octave bands is described. imc Wave also supports the use of both methods of calculating sound power within a single project.

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To switch between calculation types, we call the sound power measurement's configuration dialog. This is done by selecting the item "Configuration" in the main "Sound power" menu, or by clicking on the corresponding button in the Sound Power Analyzer toolbar.

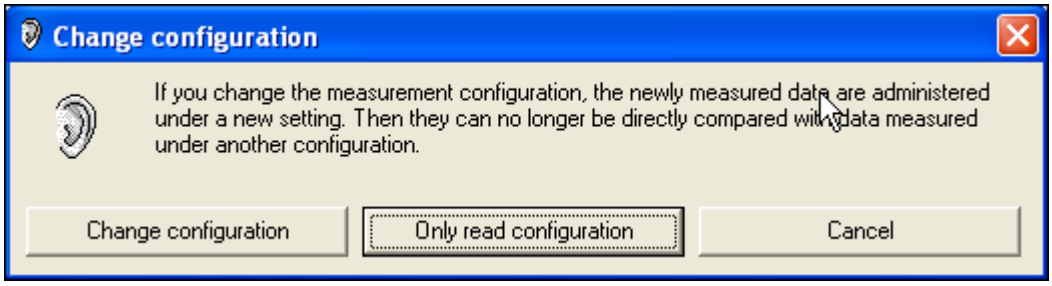
Change configuration
If you change the measurement configuration, the newly measured data are administered under a new setting. Then they can no longer be directly compared with data measured under another configuration.
Change configuration
Only read configuration
Cancel

Fig. 158: Confirmation prompt for opening the configuration dialog

The confirmation prompt shown above then appears. We wish to change the configuration and take into account that this will automatically set up a new measurement. So we click on the button "Change configuration".

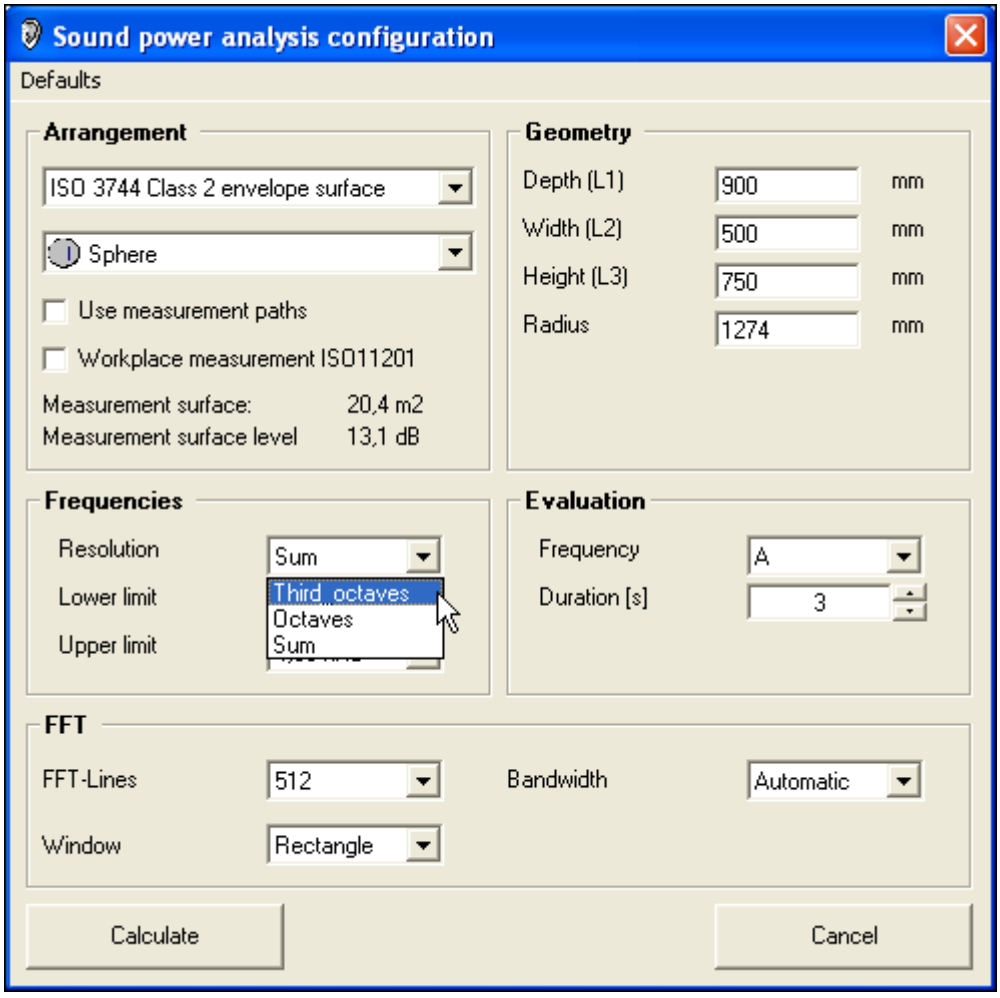

Fig. 159: Changes in the Configuration dialog

In the configuration dialog, we switch the resolution from Sum to 1/3-octaves. All other settings remain intact.

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We exit the dialog by clicking on the button “Calculate”, which sets up a new measurement.

The background noise and room correction values are now no longer occupied automatically, since we have changes the resolution. So we will need to find these values over again.

The evaluation now refers to the frequency bands. The columns Level and Background noise are now the energetic mean values in the frequency bands.

22.6.3.1 The analyzer’s definitions dialog

The manner of proceeding is as above at the beginning. We activate all necessary input channels in the definitions dialog and assign them to microphones. Then we open the dialog for the measurement results (Project Explorer – Sound power analyzer – Measurements)

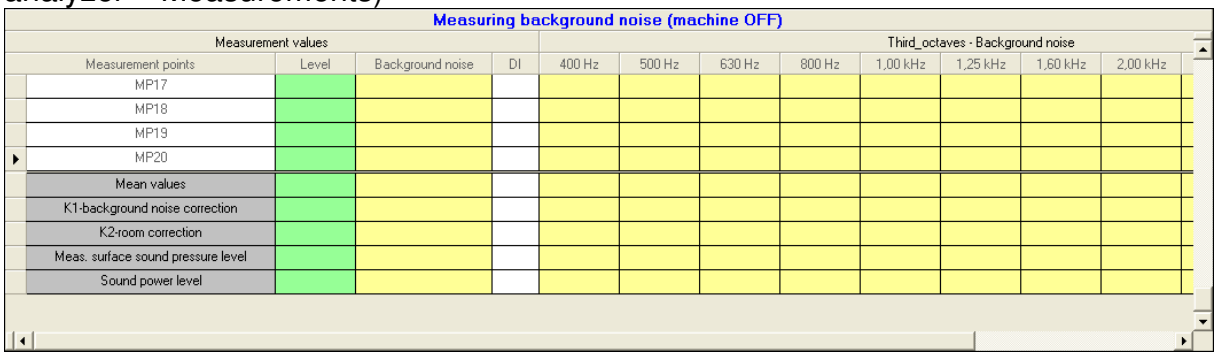

Fig. 160: Measurements dialog showing evaluation in (1/3-) octave bands

The background noise and room correction will be computed using the frequency bands this time, instead of measuring sound power using the aggregate level, which computes a frequency-selective measurement surface sound pressure level. These values for the various frequency ranges on the measurement surface are then combined to an overall sound power.

22.6.3.2 Determining background noise

The first thing is to re-measure the background noise, since we have merely determined its aggregate level. To do this, we switch back to measurement of background noise, selecting the item “Measuring background noise” in the main “Sound power” menu.

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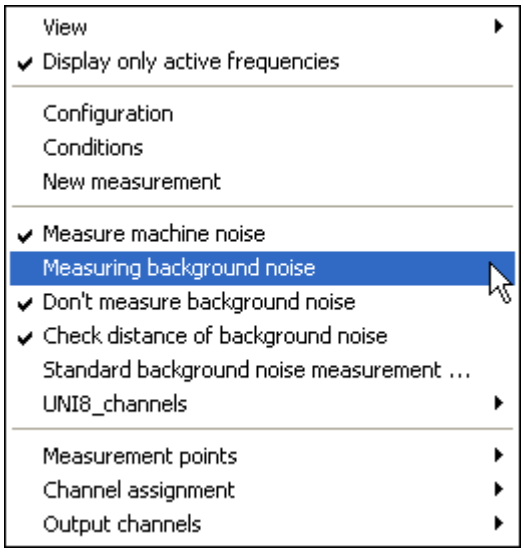

Fig. 161: Using the analyzer's menu to switch to measurement of background noise

We now deactivate the measurement object and measure the background noise. We prepare measurement and then start it. To do this use the toolbar buttons (Prepare) and (Start).

At the end of the measurement, the measurement results are displayed in the dialog.

Measuring background noise (machine OFF)

Measurement values				Third_octaves - Background noise							
Measurement points	Level	Background noise	DI	400 Hz	500 Hz	630 Hz	800 Hz	1,00 kHz	1,25 kHz	1,60 kHz	2,0
MP2		29,99		20,59	19,71	19,90	21,36	21,78	19,96	18,08	1
MP4		29,57		19,71	19,58	19,16	20,69	21,41	19,23	18,44	1
MP6		29,25		19,37	19,84	20,14	19,37	19,77	17,98	18,26	1
MP8		29,89		19,64	19,08	20,08	20,99	21,66	20,08	18,26	1
MP10		29,39		20,20	19,90	20,26	19,37	20,02	18,61	18,35	1
MP12		30,41		20,74	20,43	20,64	22,13	22,02	21,32	17,78	1
Mean values											
K1-background noise correction											
K2-room correction											
Meas. surface sound pressure level											
Sound power level											

Fig. 162: Measurement results of the background noise measurement

We can then define this measurement as the default measurement for the background noise. The procedure matches the one described above.

22.6.3.3 Determining room correction with the reference sound source

Next, we must determine the room correction for the individual frequency bands. Here, too, the measurement results of the prior measurement using the aggregate level are not available to us.

We switch back to machine noise by selecting the item "Measure machine noise" in the main Sound power menu.

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Then we return the reference sound source to the test object's intended position, turn the reference source on and start the measurement. Once the measurement time has elapsed, the measurement results are entered in the table.

Measuring machine noise (machine ON)

	Measurement values			Third_octaves - Machine noise								
Measurement points	Level	Background noise	DI	400 Hz	500 Hz	630 Hz	800 Hz	1,00 kHz	1,25 kHz	1,60 kHz	2,00 kHz	2,50
MP2	65,36	29,99	-2,38	42,22	42,96	46,83	47,46	57,35	52,56	51,33	50,63	57,
MP4	70,36	29,57	2,61	43,35	44,82	49,36	50,73	58,41	58,61	57,52	57,63	61,
MP6	65,54	29,25	-2,20	37,60	38,61	41,90	38,98	52,31	52,71	50,69	55,52	55,
MP8	65,48	29,89	-2,26	41,86	43,25	47,29	47,62	58,10	52,01	50,05	56,33	58,
MP10	67,29	29,39	-0,46	39,54	40,35	43,88	41,78	55,39	54,09	53,96	58,13	56,
MP12	69,51	30,41	1,77	43,92	43,94	48,39	50,44	57,65	56,12	59,09	60,75	61,
Mean values	67,74	29,77		41,91	42,79	46,95	47,85	56,96	55,05	55,18	57,43	59,
ackground noise corre				0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,
K2-room correction												
surface sound pressur	67,74	29,77		41,91	42,79	46,95	47,85	56,96	55,05	55,18	57,43	59,
Sound power level	87,77	49,79		61,93	62,82	66,97	67,87	76,99	75,07	75,20	77,45	79,

Fig. 163: Results of reference sound source measurement

The measurement results are now displayed without the room correction. Next we must enter the values determined by the reference sound source in the dialog "Conditions". To do this, we open the dialog by selecting the item "Conditions" in the main "Sound power" menu.

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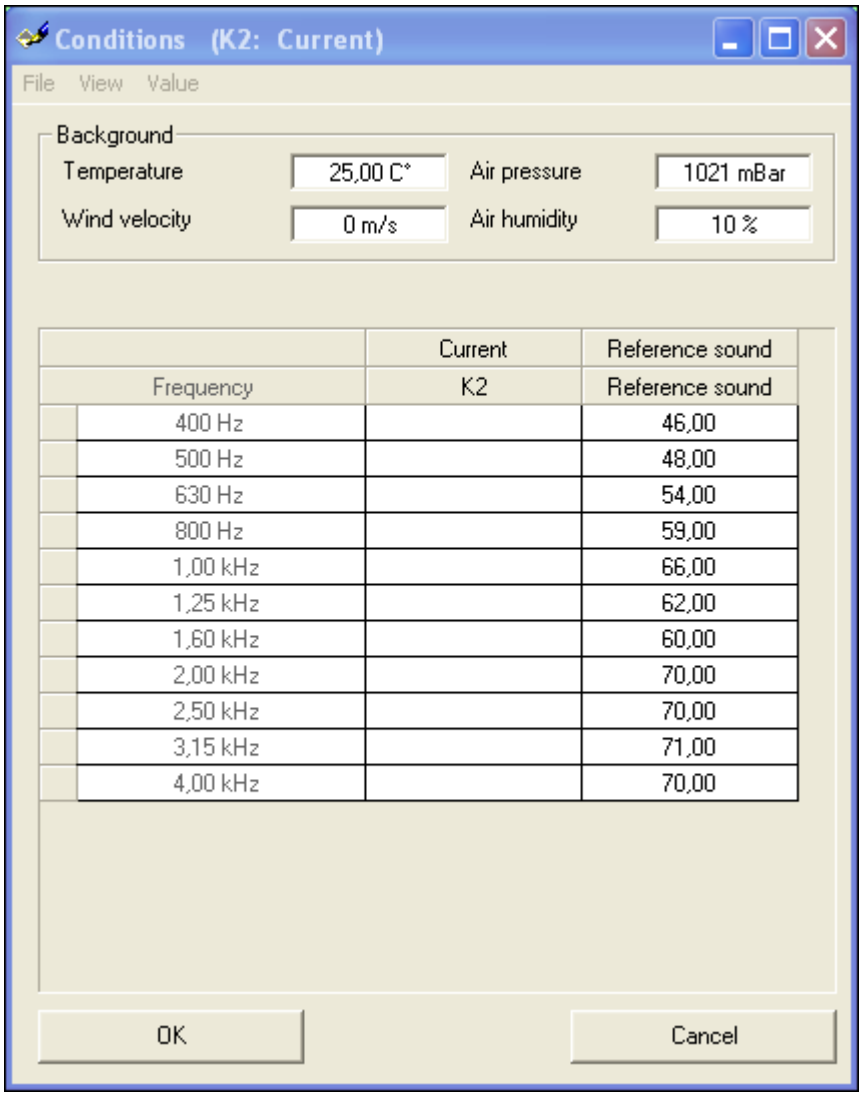

Fig. 164: Sound power values supplied by the reference sound source

Now we enter the values supplied by the reference sound source for the separate frequency bands. The correction values are computed when we select the menu item “Value – Calculate with reference source”

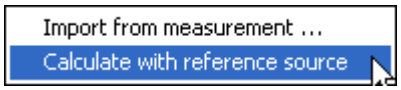

Fig. 165: Computing correction factors using the reference sound source

The correction values are now computed for each frequency band and displayed in the K2 column.

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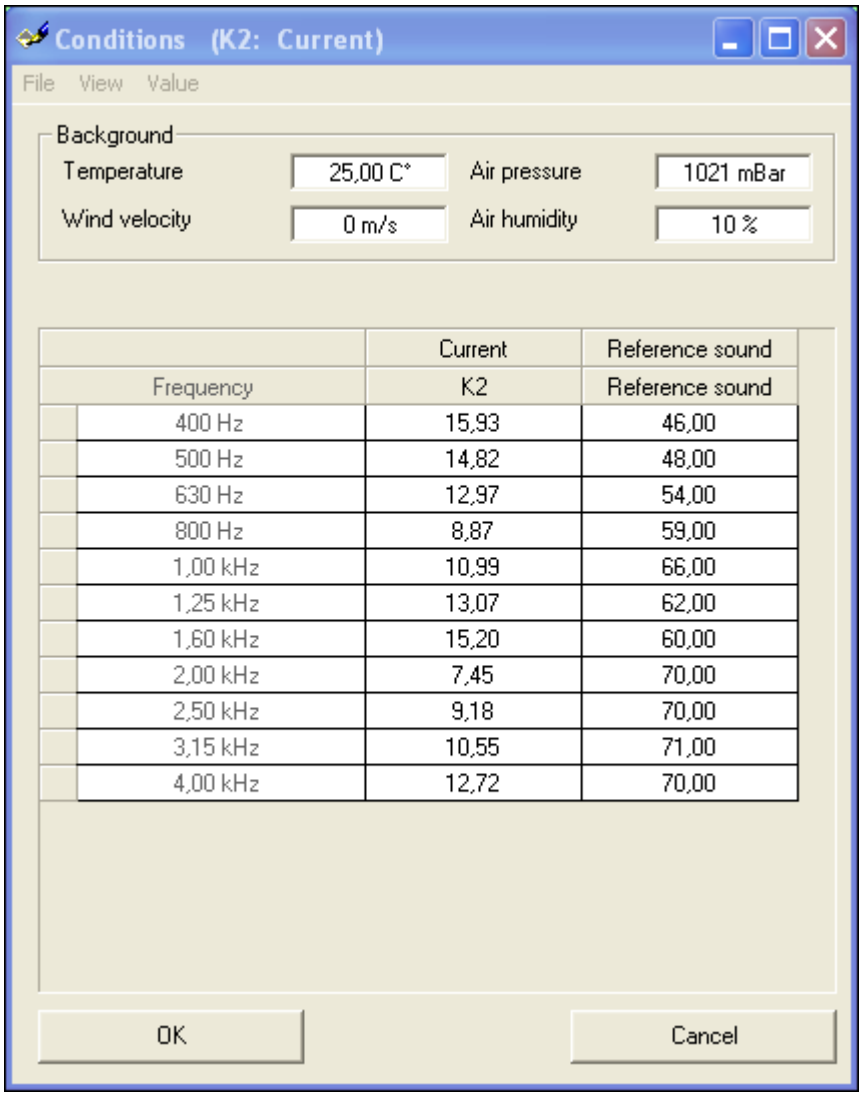

Fig. 166: Room correction results

Now we can exit the dialog again. To do this we click on the button “OK”, since we wish to apply the computation results. Once they have been applied, the analysis of the last measurement is restarted and the measurement results along with the calculated K2- room correction values are displayed in the dialog “Measurement”. The resulting sound power level for the reference sound source must be the same as for calculation by means of the sum. This is the necessary result, since we have calculated the room correction based on the reference sound source. If this is not the result you obtain, an error was made in the procedure which we must correct before performing the measurement of the test objects.

22.6.3.4 Measurement of the measurement object’s sound power

If the computation of correction values was satisfactory, we can proceed with taking measurements of a test object. To do this, we first set up a new measurement. This is done by selecting the item “New measurement” in the main “Sound power” menu.

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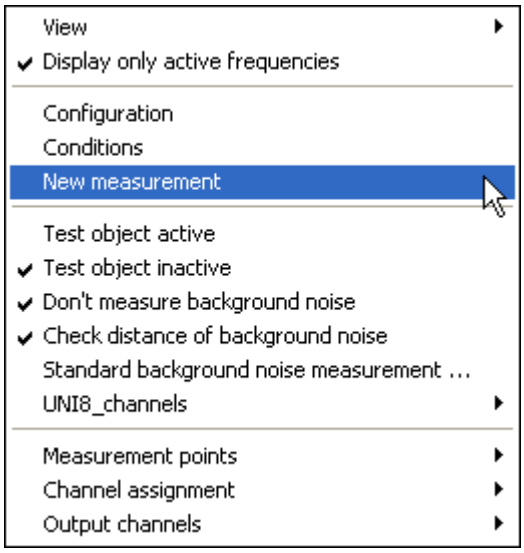

Fig. 167: Setting up a new measurement

We then have a new entry under the heading “Data” in the Project Explorer.

Measuring machine noise (machine ON)

Measurement values				Third_octaves - Machine noise						
Measurement points	Level	Background noise	DI	400 Hz	500 Hz	630 Hz	800 Hz	1,00 kHz	1,25 kHz	1,60 kH
MP2										
MP4										
MP6										
MP8										
MP10										
MP12										
Mean values										
K1-background noise correction										
K2-room correction				15,93	14,82	12,97	8,87	10,99	13,07	15,20
Meas. surface sound pressure level										
Sound power level										

Fig. 168: New measurement in the measurement dialog with room correction values entered

Now it’s possible to run a new measurement. Once the measurement has been completed, the measurement results are displayed in the table. The background noise correction is applied from the previously defined measurement.

Measuring machine noise (machine ON)

Measurement values				Third_octaves - Machine noise						
Measurement points	Level	Background noise	DI	400 Hz	500 Hz	630 Hz	800 Hz	1,00 kHz	1,25 kHz	1,60 kH
MP2	61,71	29,64	-2,85	35,82	42,22	45,81	50,14	47,44	47,65	52,60
MP4	67,72	29,38	2,31	37,22	42,86	48,38	51,14	52,95	55,31	56,73
MP6	61,78	29,21	-2,94	31,54	36,62	42,27	44,30	44,81	49,09	50,60
MP8	62,53	29,48	-1,99	36,01	43,09	46,80	48,32	47,60	48,49	50,58
MP10	63,89	29,68	-0,93	32,69	38,41	43,87	45,30	47,54	50,82	54,08
MP12	67,35	31,05	2,63	37,97	42,22	46,56	53,19	50,90	51,53	59,71
Mean values	64,91	29,79		35,77	41,49	46,05	49,78	49,38	51,32	55,39
K1-background noise correction				0,00	0,00	0,00	0,00	0,00	0,00	0,00
K2-room correction				15,93	14,82	12,97	8,87	10,99	13,07	15,20
Meas. surface sound pressure level	54,03	18,40		19,84	26,67	33,08	40,91	38,39	38,25	40,19
Sound power level	74,05	38,42		39,86	46,69	53,10	60,93	58,41	58,27	60,21

Fig. 169: Measurement results for the test object with all correction values calculated by means of 1/3-octaves

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This concludes the inspection and we have thus determined the results for the sound power.

22.6.4 Measurement of sound power in reference to a reference quantity

Measurement of sound power in reference to a reference quantity is basically an extension of the two previously described procedures. In principle, both procedures described above can be used for measurement with a reference quantity.

The reference quantity defines the measurement's resolution by subdividing an input range into classes of constant width. In our example, we will use the rotation speed of the drill discussed above as the reference quantity, and investigate the RPM-range from 100 to 1100 RPM. The class width shall be set to 200 RPM, so that 6 measurements are performed.

22.6.4.1 Configuration of the reference quantity

As a first step, we must link the incremental counter with the drill, which is most easily done by means of the drill chuck. This incremental counter is connected with the incremental encoder interface's first input channel. The measurement channel's configuration is made in a manner similar to configuration of the audio input channels.

The configuration dialog is called by double-clicking on the item "Input channels–Incremental encoder".

We define the incremental counting in accordance with the number of markings, in this case 3600 pulses per revolution, and set the maximum rotation speed to 7500 rev/min. As the mode for the incremental counter output, we use the RPM-mode.

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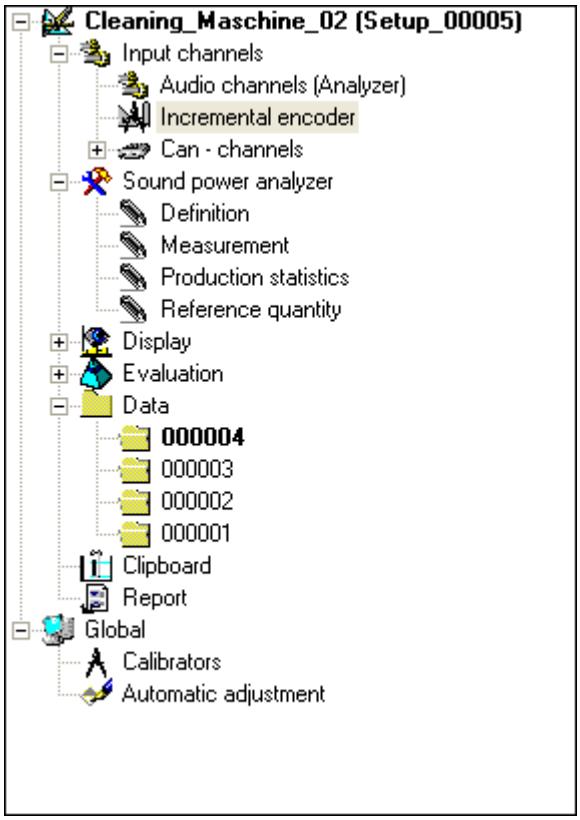

Fig. 170: Calling the incremental counter's configuration dialog

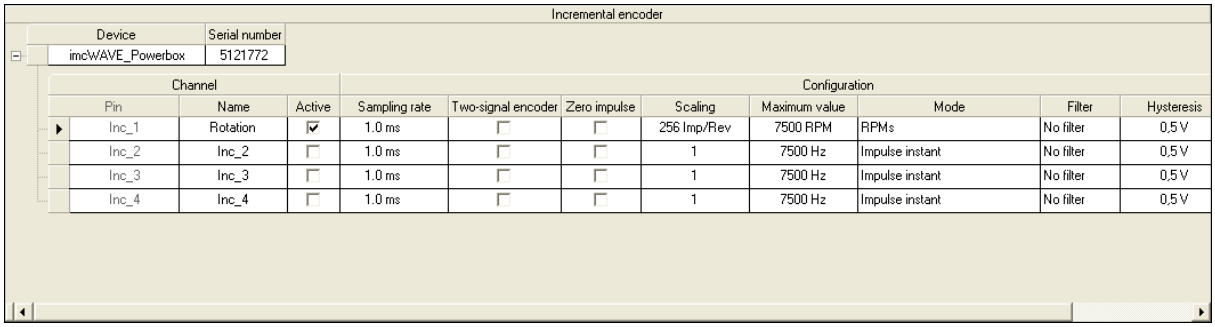

Fig. 171: Defining the reference quantity: rotation speed

Thus the configuration of the reference quantity as an input channel signal is completed. We still must notify imc WAVE that this channel is to be used as the reference quantity, and in which range the measurements are to be carried out. To do this, select the entry "Reference quantity" in the Project Explorer under the heading "Sound power analyzer".

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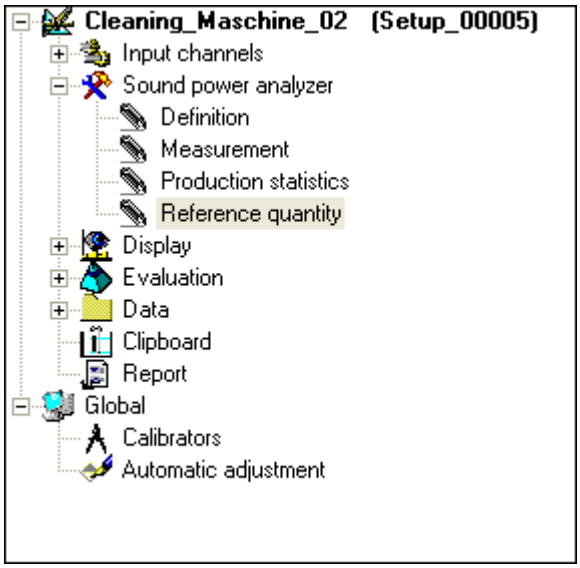

Fig. 172: Calling the definitions dialog for the reference quantity

In the dialog below, we can now configure the reference quantity.

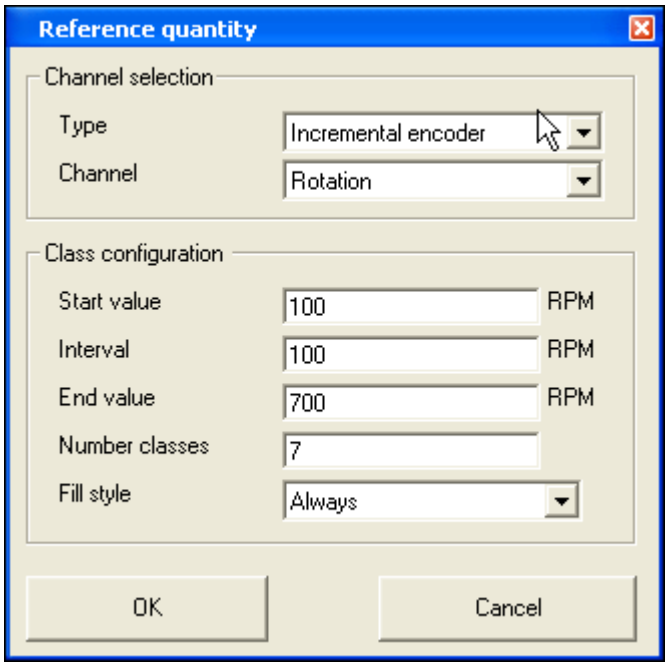

Fig. 173: The definitions dialog for the reference quantity

First, we select under “Channel selection” the type “Incremental encoder” and then under “Channel” the defined incremental encoder channel “Inc_1”.

Under “Class configuration” we next define the range and class partitioning in accordance with the specifications made above.

Once we have made all the entries, we can close the dialog by clicking OK and have concluded the process of defining the reference quantity.

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22.6.4.2 Preparing display of the measured results

Next we prepare the measurement, since in the preparation process, all data sets will be set up which we will need for displaying the measured data in a curve window. To launch measurement preparation, click on the toolbar button .

After preparation of the measurement, we open the curve window assistant by double-clicking on the entry “Display – Curve window - Assistant” in the Project Explorer.

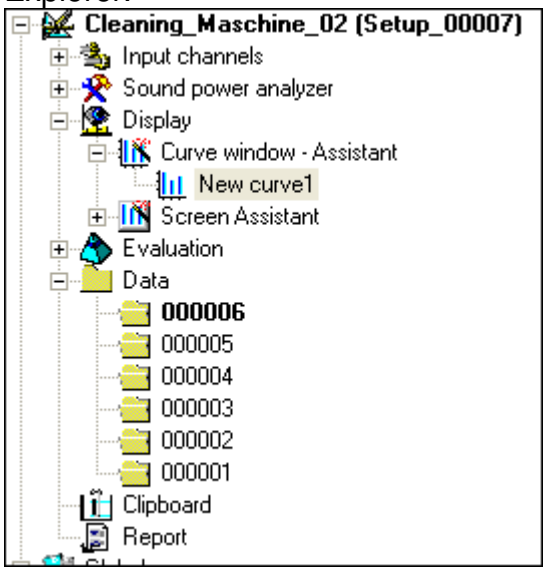

Fig. 174: Calling the Curve window Assistant

We now compile various curve window configurations for display of the measured results. To do this, we begin by opening an empty curve window or click on the button “New” in the Assistant’s toolbar.

First, we display the sound power levels of the individual classes. This is a so-called XY-display. Begin by opening the dialog “More waveforms..”.

Now drag the waveforms Sound_Power_Level and Class_X into the curve window, highlight both waveforms and select as the display style “y-x-y-x”, which causes the first waveform to be displayed in the y-axis, and the second waveform in the x-axis. The waveform “Class_X” is the record of the reference quantity with which the measurement was performed. This makes it possible to plot the sound power level over the reference quantity.

Now if you close the dialog with “OK”, the curve window will appear as shown below. Additionally, you can assign the display style “Fat dots” to the “Sound power” curves. This settings option is available in the lower right portion of the toolbar.

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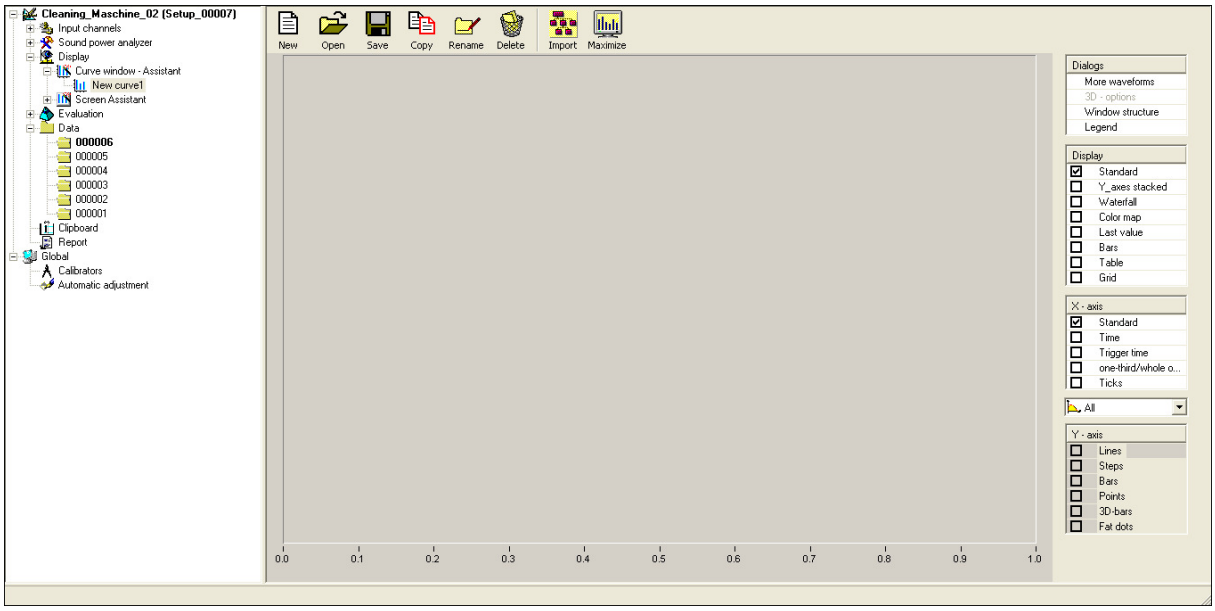

Fig. 175: Display of the sound power over the class number

Next, we display the reference quantity. To do this, we open a new template using the button “New” and then select the dialog “More waveforms..”. In this dialog, we drag the waveform “Inc_1”, the reference quantity we selected, into the curve window. We close the dialog and then we can click on “Grid” in the toolbar at right under “Display”. This inserts grid lines in the curve window.

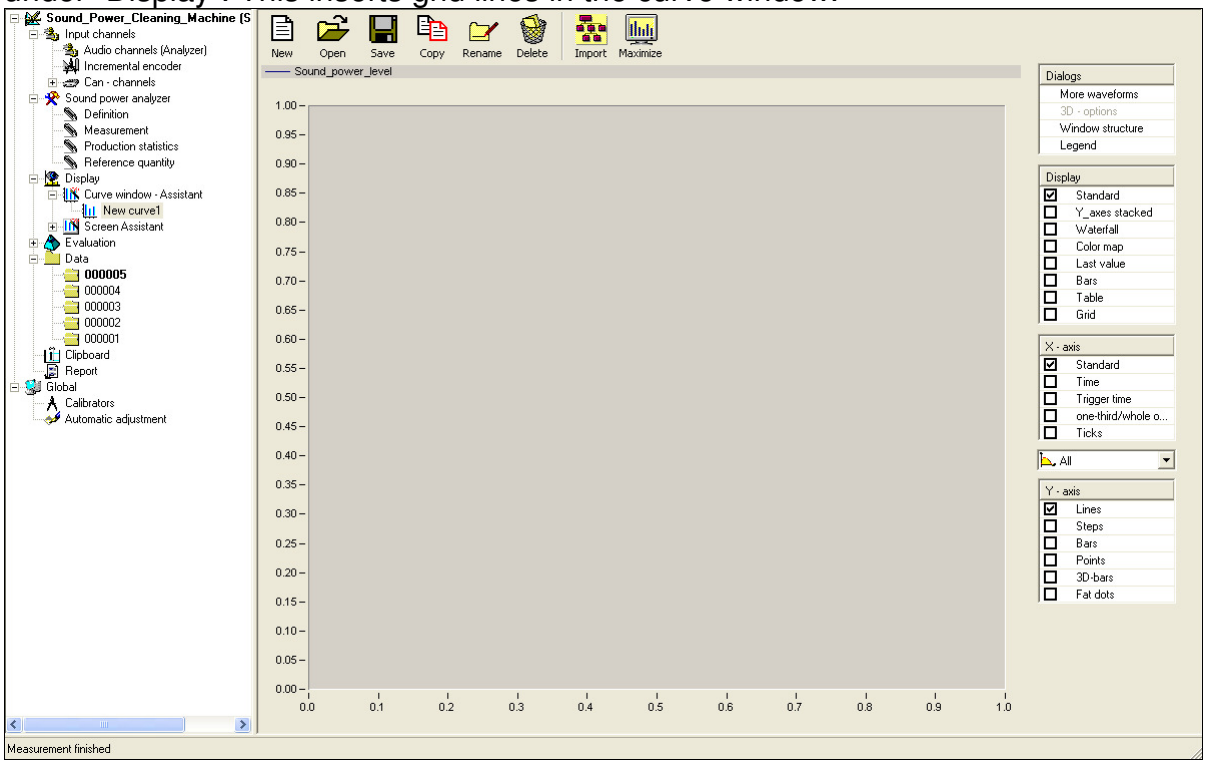

Fig. 176: Plotting the Sound_power_level over the classes

Additionally, it is now possible to duplicate the class partitioning in the curve window. To do this, double-click on the curve window’s y-axis. In the following dialog, select the entry “Fixed range: min, max” in the pop-down list “Range selection” and enter under “Minimum” the value 100 revs/min and for “Maximum” the value 700 revs/min. Set the number of markings to 7.

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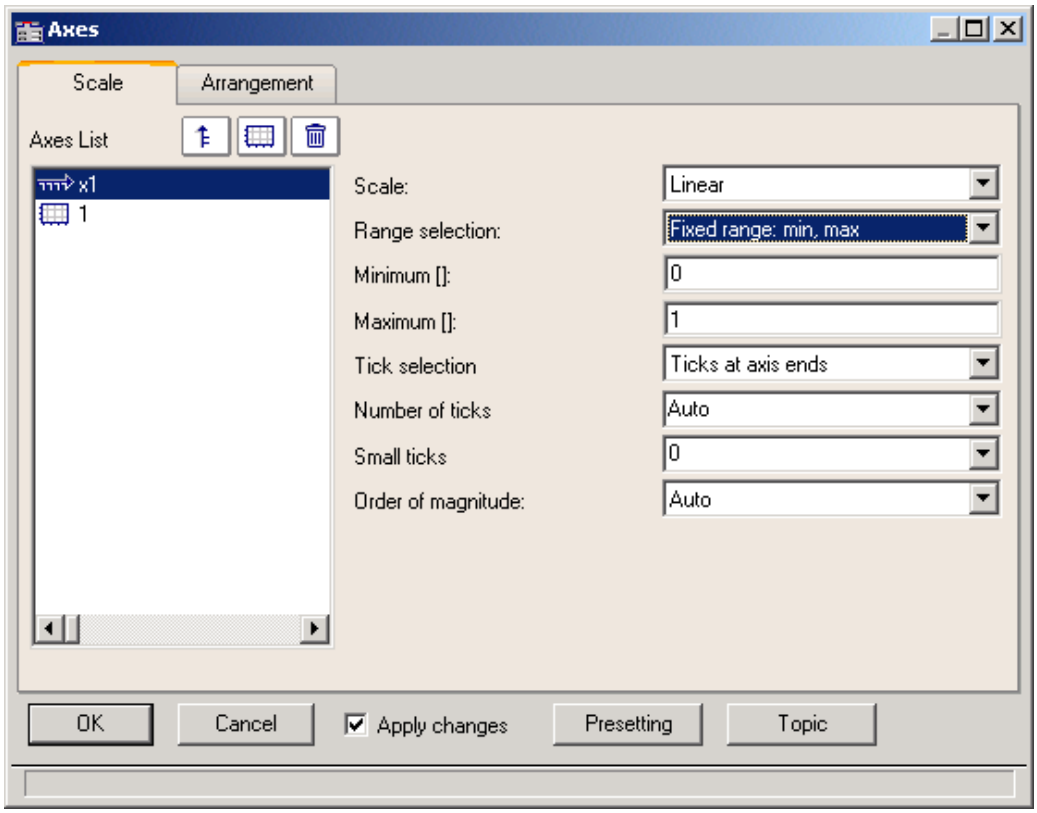

Fig. 177: Scaling the y-axis for the reference quantity

As an additional quantity, we can now display the classes in a curve window. To do this, select a new curve window, as described above, and display the quantity “Class_X” in it.

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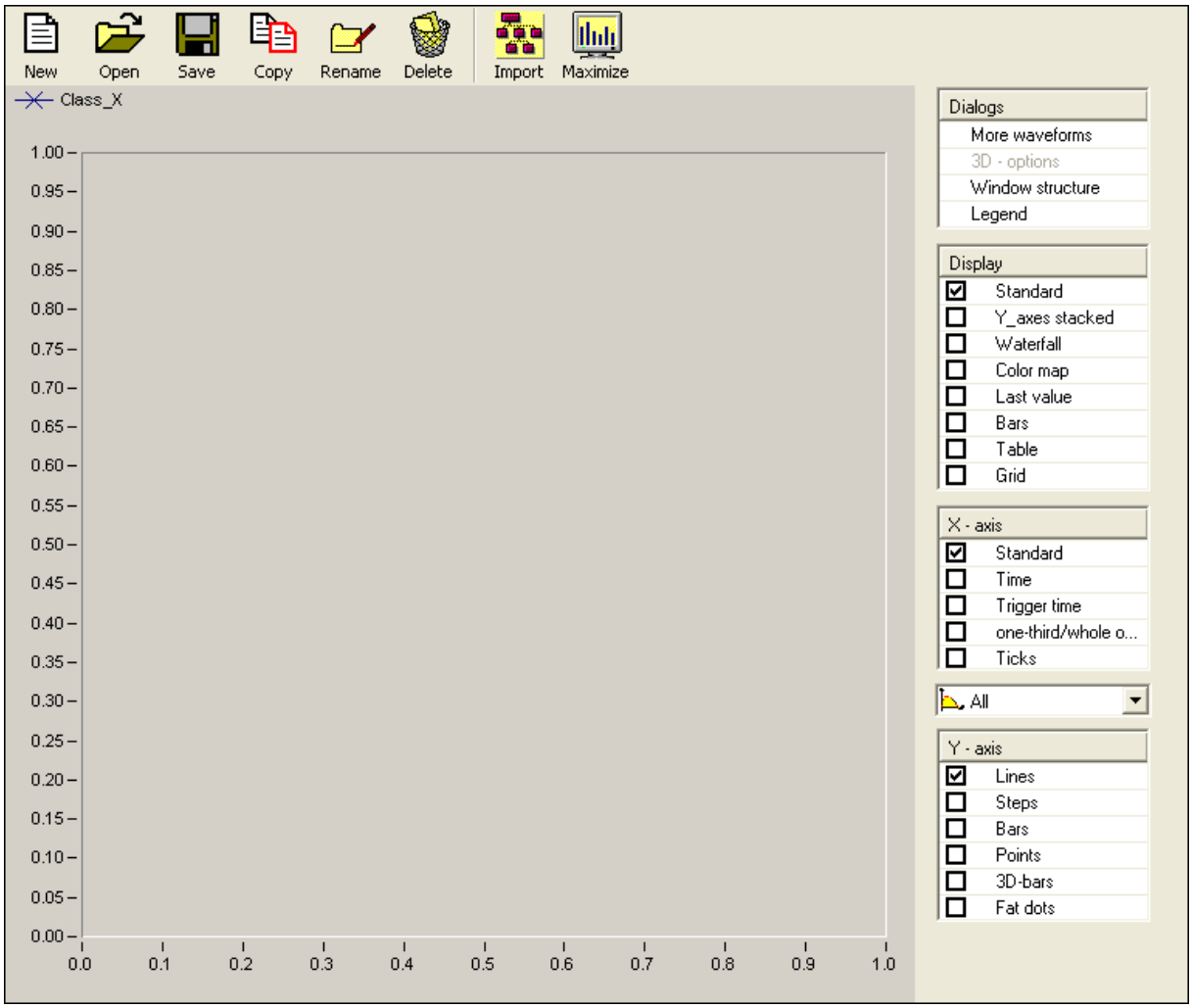

Fig. 178: Displaying the quantity Class_X in a curve window

Now we display the 1/3-octave spectra of the sound power. To do this, select another new curve window and with the help of the “More waveforms..” dialog, drag the waveform “Third_octaves” into the curve window. As the display style, we select “Waterfall”.

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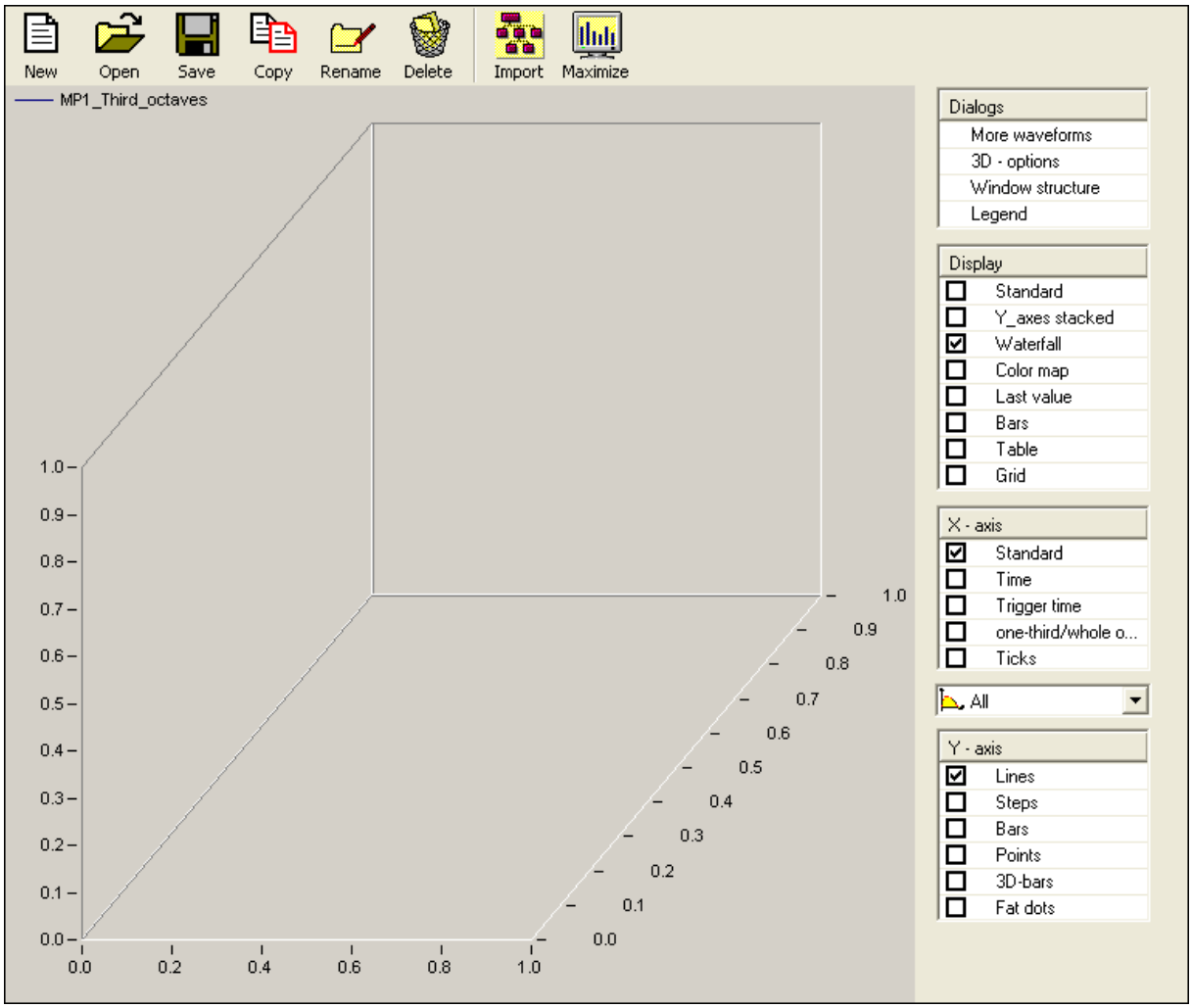

Fig. 179: Display of the quantity Third-octave in a curve window

Now we have configured four curve windows which can join in one screen using the Screen-Assistant. Select the entry “Display – Screen Assistant” in the Project Explorer.

In the Screen-Assistant’s dialog we use the button “New” to set up a new screen and set the partitioning to “Four parts”, thus obtaining four placeholders with empty curve windows. Use Drag&Drop to assign four curve configurations from the Project Explorer to these four placeholders. The dialog should then appear as shown below.

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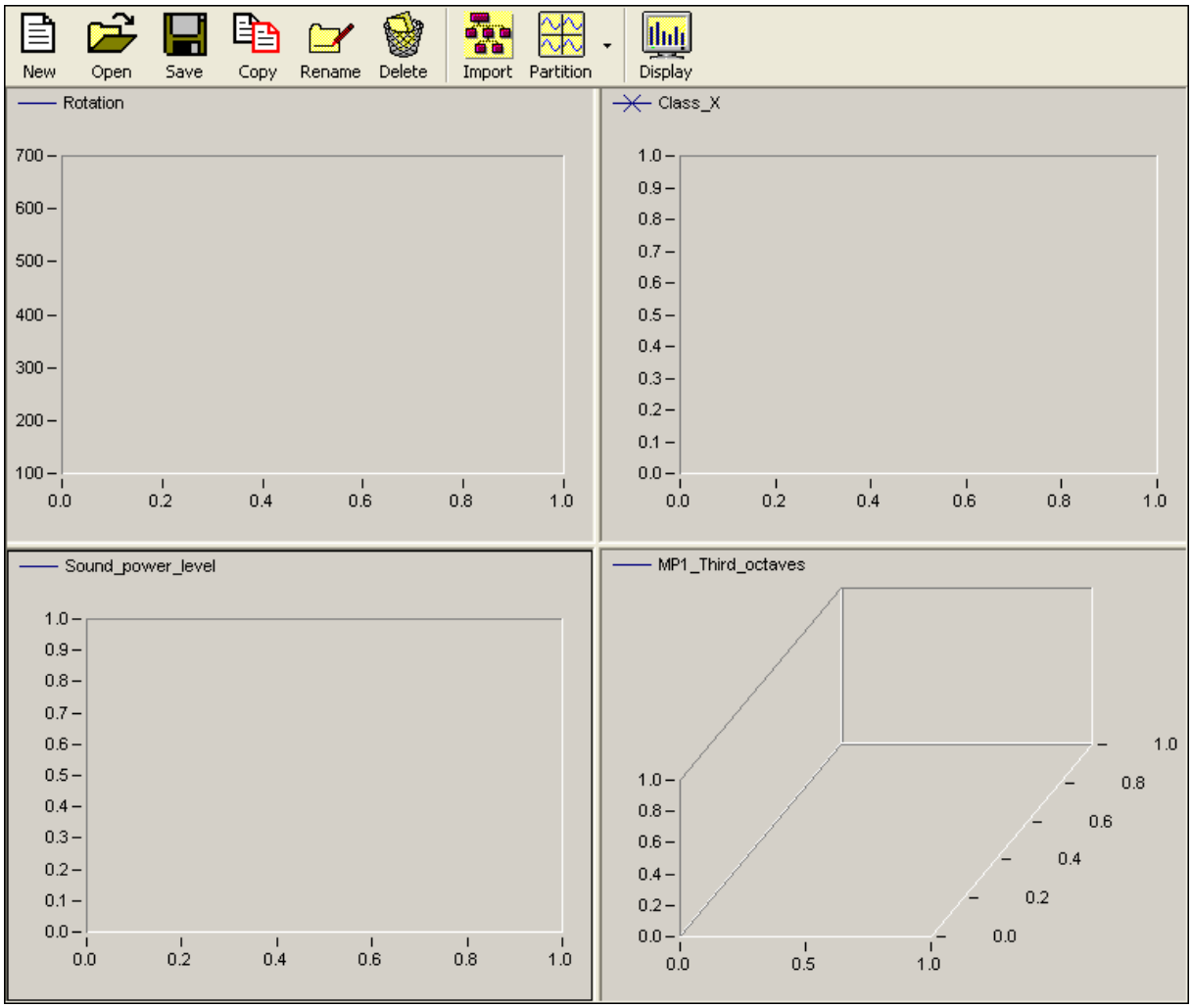

Fig. 180: Display of four-tiled screen

Once having completed the screen configuration, use the “Display” button in the toolbar to close the Assistant and to switch to normal display.

22.6.4.3 Running a measurement

We start the measurement now by clicking on the toolbar button . Then imc WAVE monitors the reference quantity and starts a measurement each time the reference quantity’s signal enters a class into which no previous measured value fell. Once the reference quantity has passed through all classes, the measurement stops automatically. After each measurement, an analysis including computation of the sound power level for each respective class is performed immediately. The results are outputted in the curve windows and in the tables of the appropriate dialogs.

The following figures show measurement results displayed in both the curve window and in the table.

With the tabular display, the class to be displayed can be selected from the pop-down list at the table’s upper right edge. The measured results of the desired class are loaded and displayed.

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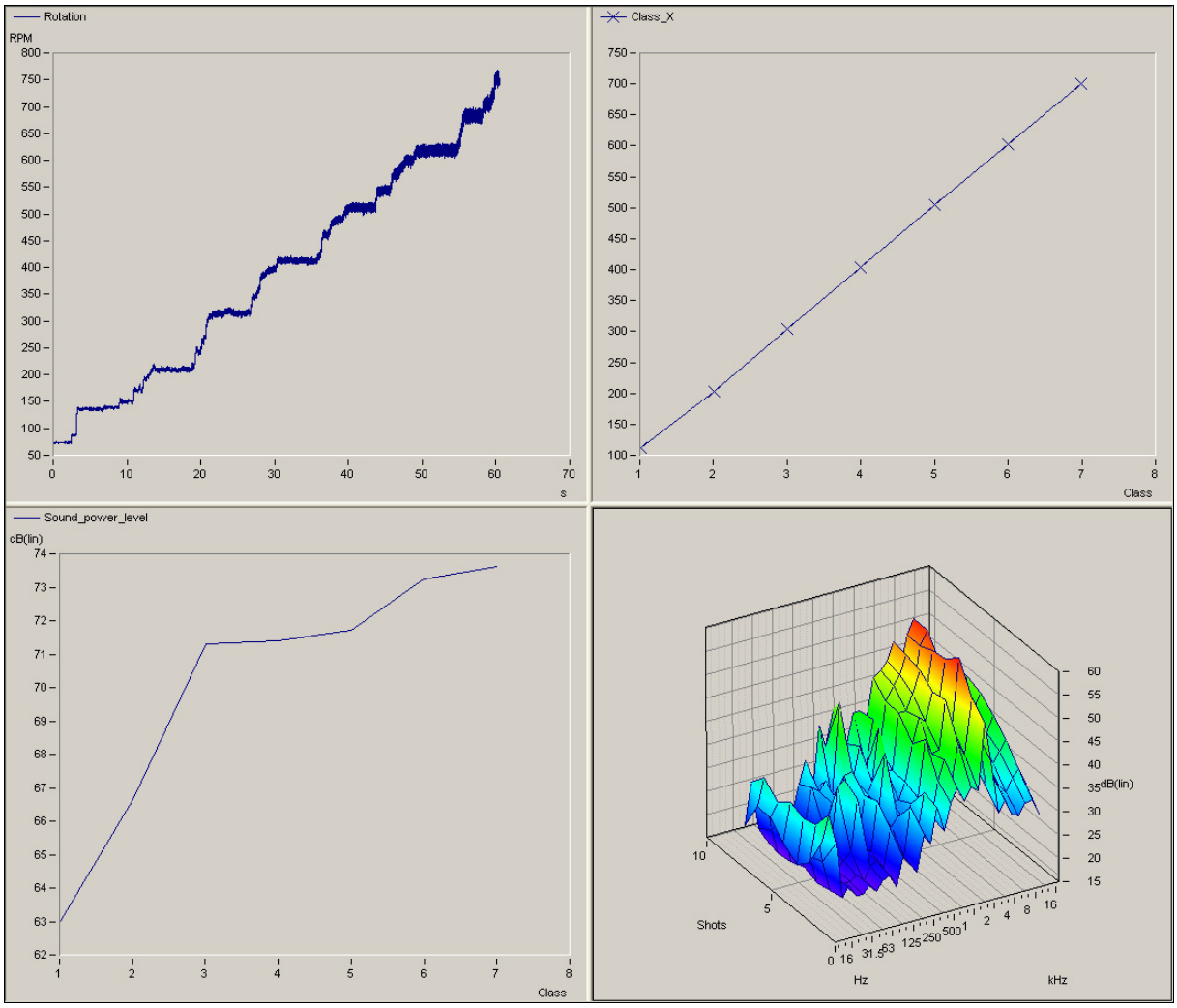

Fig. 181: Display of measured results in curve windows

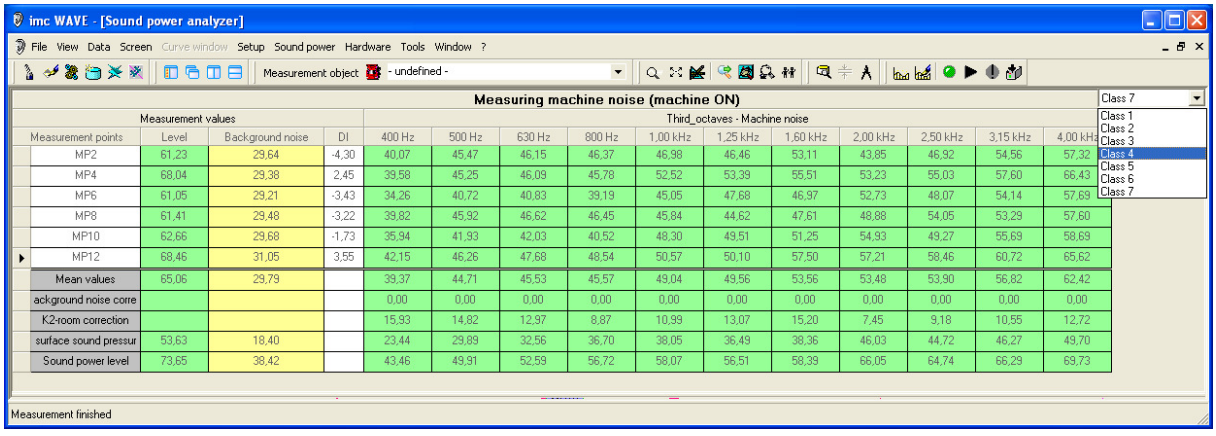

Fig. 182: Display of measured results in tabular format

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23 The Order Analyzer

The Order Analyzer is a powerful tool for calculating the spectral distribution of dynamic reference quantities. For instance, in the case of a machine revving up or winding down, it would be useful to see the spectral lines of the bearings vibrations in relation to the axle's momentary RPM value. A simple FFT analysis of the data from the run-down would "smudge" the spectral lines over a wide range of the spectrum, since FFT analysis makes reference to time and not to the axle RPM. Order analysis, by contrast, makes reference to the rotational angle so that the same amount of revolutions is analyzed no matter what the current RPM value is. Thus, data acquisition for slower rotation takes longer than for fast rotation. This re-scaling ensures that the analysis holds the spectral lines in position rather than letting them sweep through the spectrum as the RPM-value changes.

23.1 How order analysis is performed

The order analysis converts the input signal's course over time to an angle-referenced signal and calculates the spectrum of this new signal.

The user is seeking the order spectrum up to the O_{max}^{th} order for the RPM-referenced input signal, with a resolution of ΔO.

In explanation of the terms used:

- **Order line**
  An "order line" refers to the spectral line of a rotation-referenced signal.
  The 1^{st} order line means the spectral line directly correlated to the RPM-value. All other order lines refer to multiples of the RPM-value. The advantage is that order analysis works independently of the RPMs course over time.

- **Order spectrum**
  Spectrum of the rotation-referenced signal

- **Order resolution**
  means the distance between two adjacent order lines.

- **Maximum order**
  is the highest order in the spectrum calculated.

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An example will illustrate calculation of an order spectrum:

We consider a machine which has two RPM-settings.

An idealized plot of the machine's RPMs is shown below.

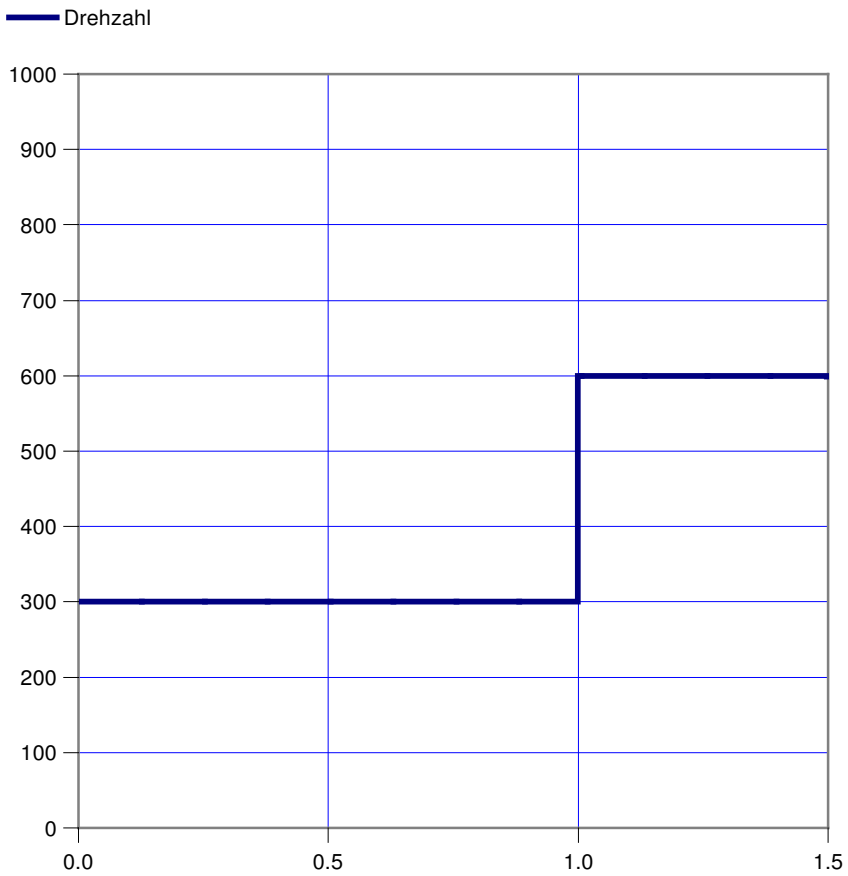

Fig. 183: Example of a machine's RPM-behavior

We see that the machine runs for 1 second at 300 RPM and then for 0.5 seconds at 600 RPM. For this run of the machine, the acceleration of a bearing is also plotted.

A spectral analysis can be used to investigate this behavior.

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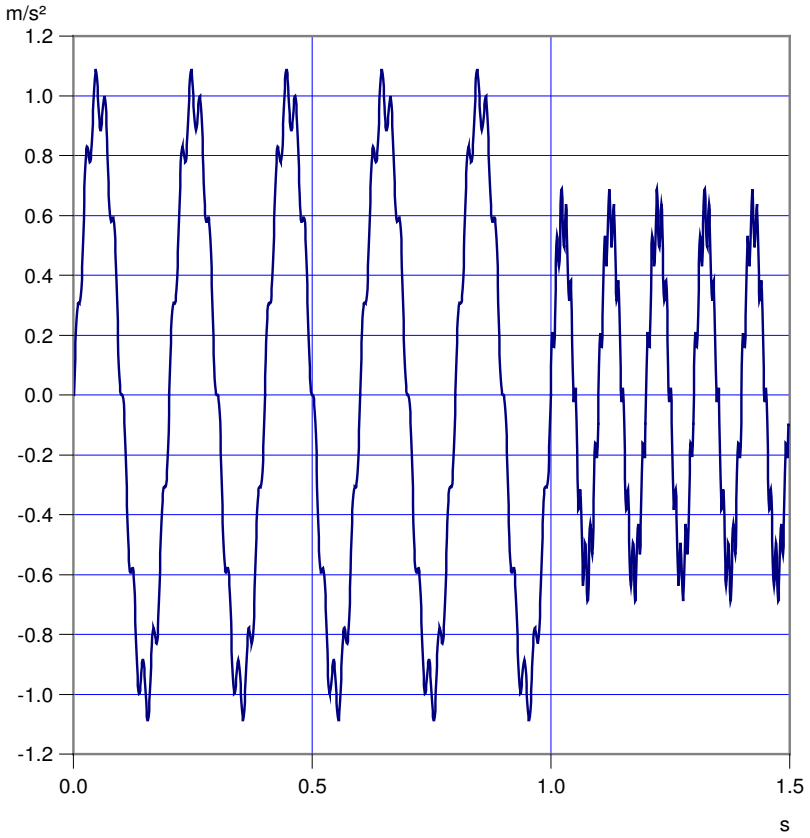

Fig. 184: Example: bearing vibration behavior

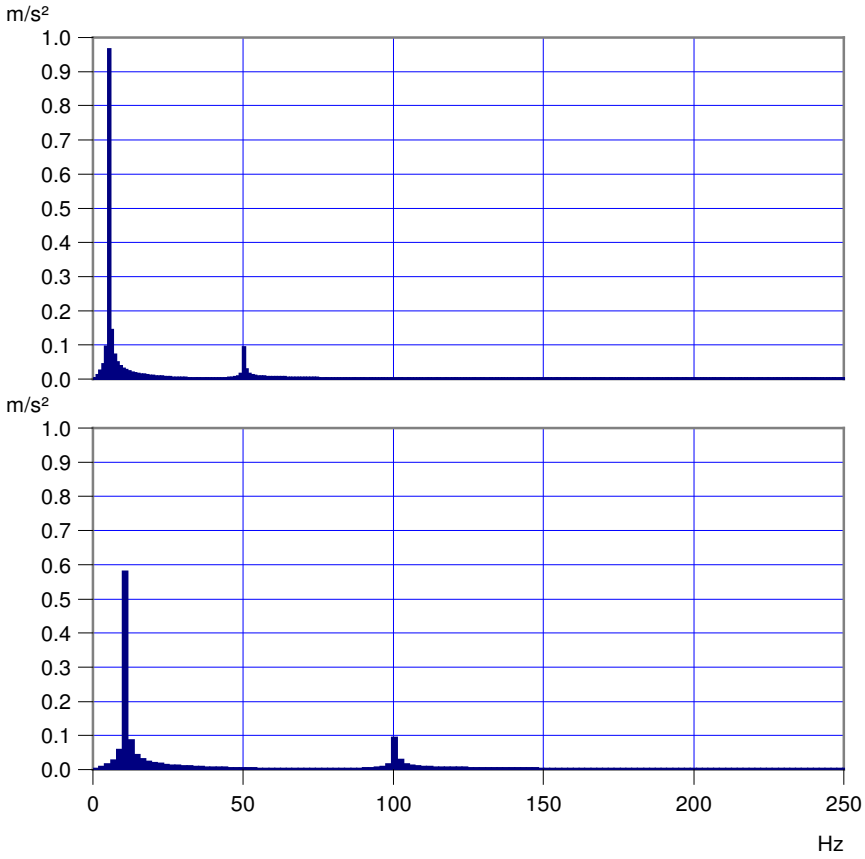

Fig. 185: Spectrum of bearing vibration in each RPM-stage

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If this signal were sampled equidistantly over revolutions instead of over time, the results would appear as shown below. One sees that in both RPM-stages the signal period is the same.

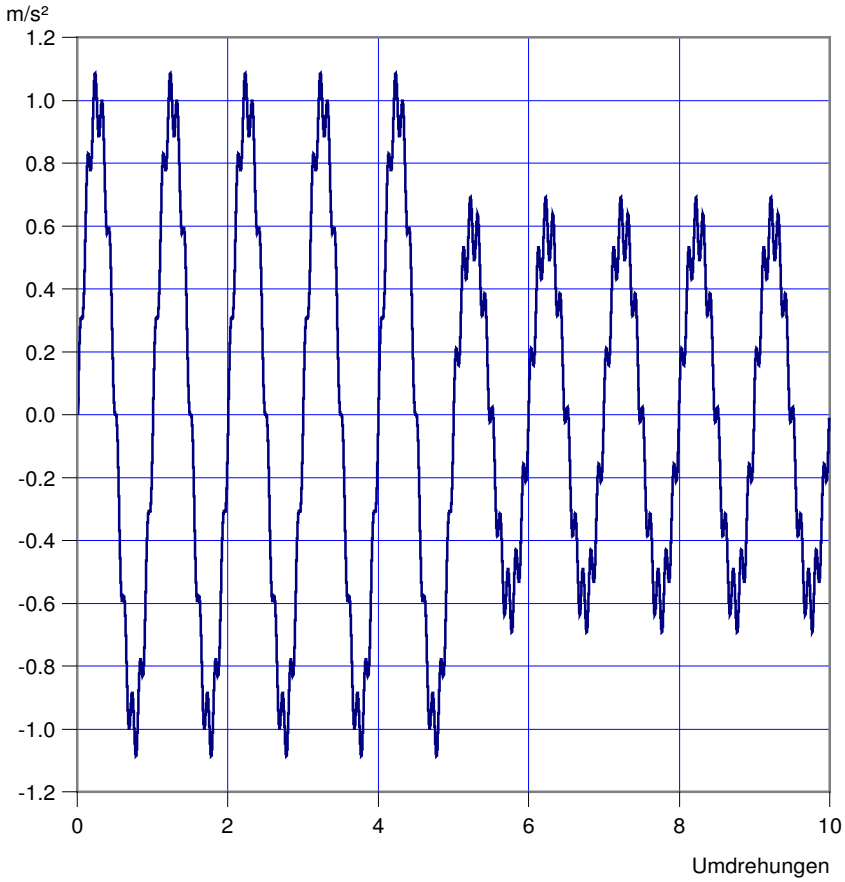

Fig. 186: Rotation-referenced bearing vibration signal in both RPM-stages

Performing an FFT-transformation of the rotation-referenced bearing vibration signal yields the order spectrum.

Here we see the difference between the order spectrum and the RPM-spectrum. In the order spectrum, any physical frequency which correlates to the instantaneous RPM is mapped onto just one spectrum line, even though the raw data reflect changing RPM values. In the RPM-spectrum, by contrast, any frequency which is correlated to the instantaneous RPM varies along with it, and thus contributes spectral lines smeared over the spectrum.

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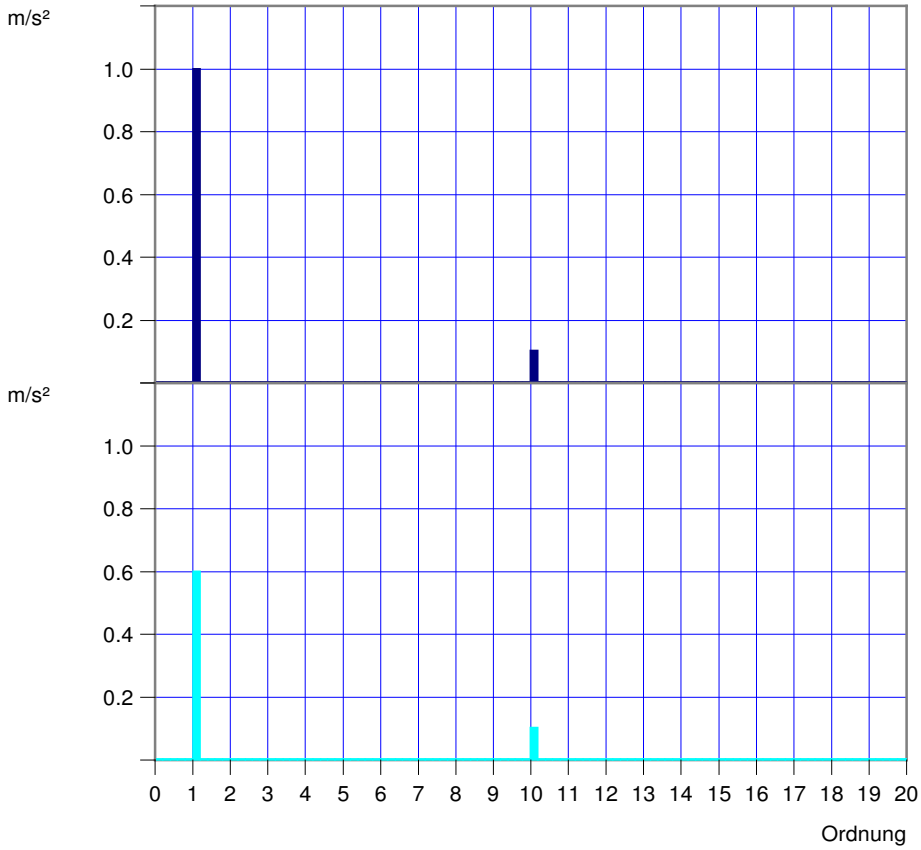

Fig. 187: Order spectrum of rotation-referenced bearing vibration in the two RPM-stages

The two spectra can also be displayed in a color map, which also immediately reveals the difference between the calculation techniques.

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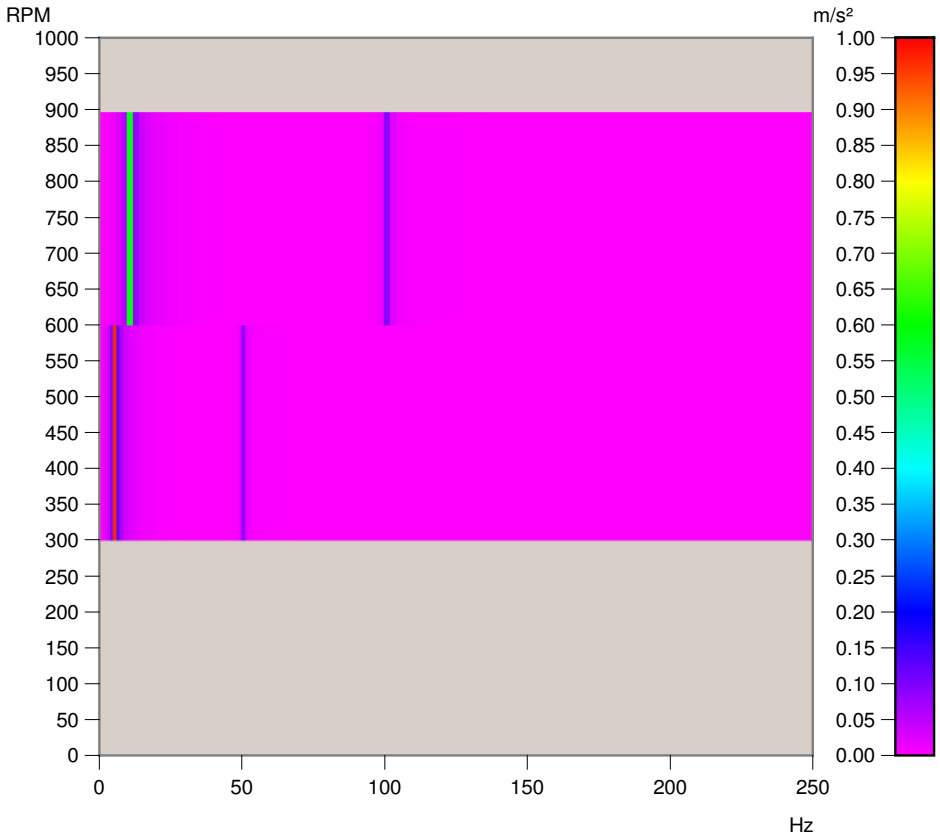

Fig. 188: Color map of RPM-spectrum

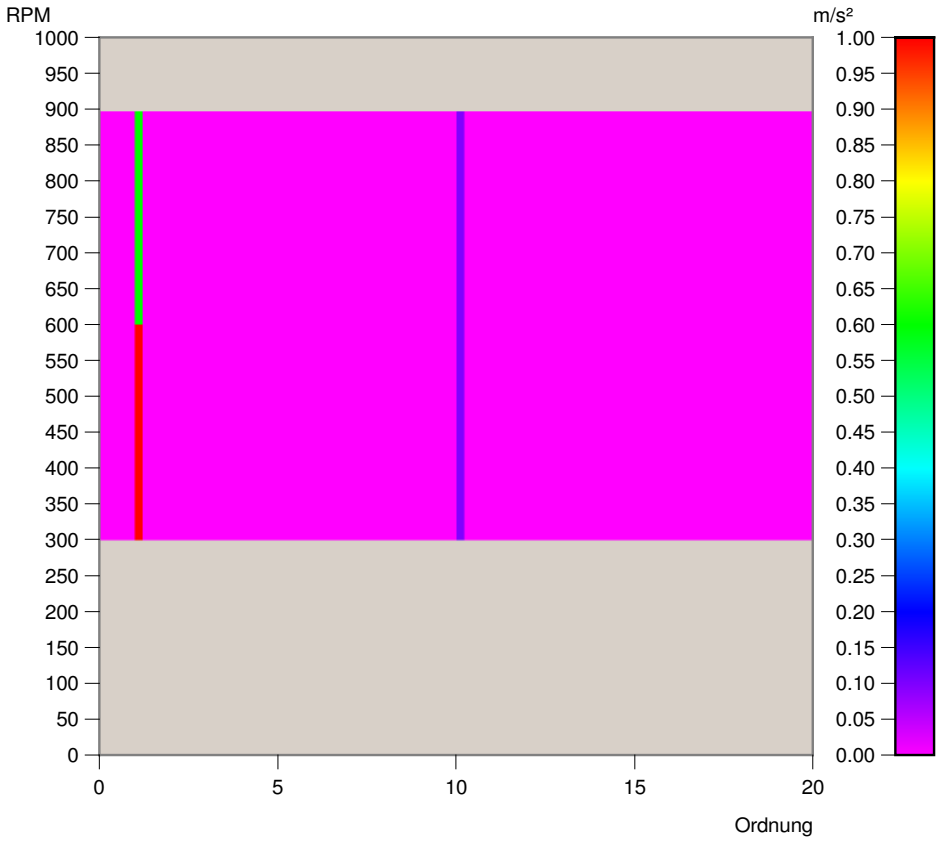

Fig. 189: Color map of order spectrum

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The example has served to illustrate the basic interpretation and display of order analysis.

23.2 The mathematical theory behind order analysis

The following flowchart represents the calculation of order analysis in imc WAVE:

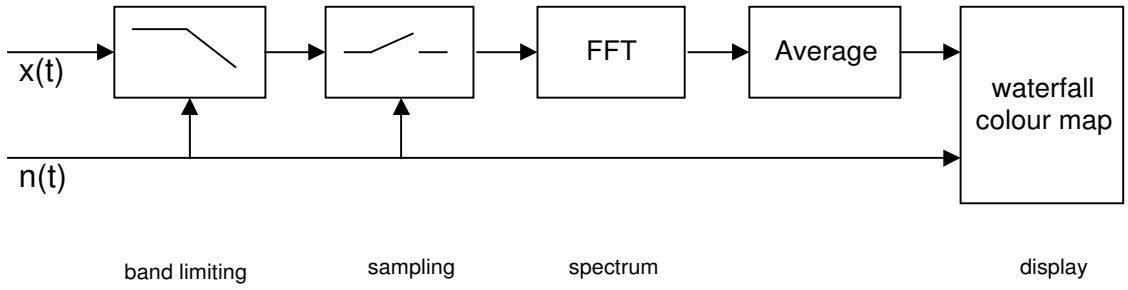

Fig. 190: Calculation scheme for order analysis

The resampling is synchronized to the RPM-value.

We now take a backward approach to studying order analysis. Since we must meet the conditions of the Sampling Theorem even in the rotation angle domain, we need, in order to calculate the spectrum,

$$N_W = 2\frac{O_{Max}}{\Delta O}$$

lines in the order spectrum. On this condition, the order spectrum's maximum order is just O_{max} and the resolution is ΔO.

From the order resolution, we can compute U, the number of revolutions for which data must be acquired.

$$U = \frac{1}{\Delta O}$$

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From U and N, the number of points, we find the signal's required resolution in the angle domain.

$$\Delta W = \frac{U}{N_W} = \frac{1}{N_W \Delta O}$$

We now have defined the rotation-referenced signal and its sampling rate:

We need N_W points of the rotation-referenced signal at a sampling interval of ΔW.

Before sampling the time-based signal in the angle domain, the signal must be band limited.

The cutoff frequency for the low-pass filter is given by:

$$f_g = \frac{n(t)}{60} O_{Max}$$

where n(t) is expressed in RPM.

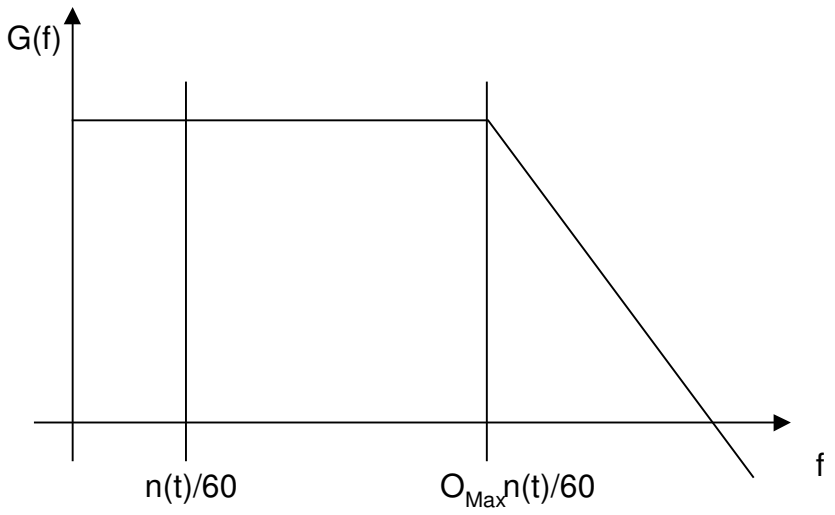

Fig. 191: Band-limiting the time-based signal before re-sampling

The minimum value for f_g, the upper cutoff frequency for the anti aliasing filter (AAF) depends on the instantaneous RPM values; without the filter, distortions will result from re-sampling. To fulfill the conditions for the Sampling Theorem, we need a time-based signal with a sampling rate of

$$f_T \geq 2 f_g$$

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The required length of the time-based signal can be calculated from the current RPM value and the number of revolutions needed to achieve the required order resolution.

$$\begin{aligned} T_G &= U \frac{60}{n(t)} \\ &= N_Z T \\ &= N_Z \frac{1}{f_T} \\ &= \frac{1}{\Delta O} \frac{60}{n(t)} \end{aligned}$$

The quantities appearing here are defined as follows:

T_G	time-signal length
$n(t)$	instantaneous RPM value
U	number of revolutions
N_Z	number of data points in time-signal
T	sampling time
f_T	sampling frequency
ΔO	order resolution

We have thus determined the parameters required of the input signal on the basis of the parameters desired for the order spectrum.

$$N_Z = \frac{1}{\Delta O} \frac{60}{n(t)} f_T$$

$$T = \frac{1}{f_T}$$

$$f_T \geq 2 \frac{n_{Max}}{60} O_{Max}$$

The sampling interval thus depends on the maximum RPM value and the highest order to be calculated for the order spectrum.
The number of data points acquired depends on the sampling frequency, the instantaneous RPM value and the desired order spectrum resolution.

The information obtained applies to data acquisition for the order spectrum. Parallel to the order spectrum, we wish also to find the RPM-spectrum.

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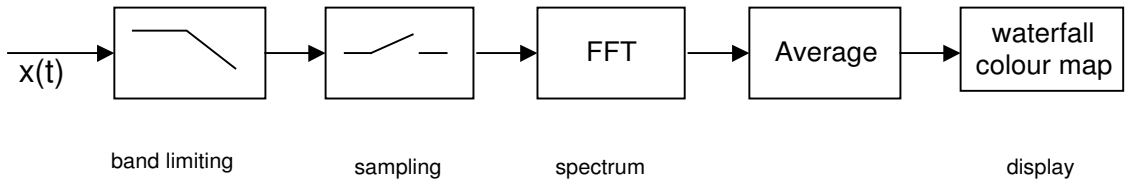

Fig. 192: Calculation scheme for rotation spectrum

The spectrum is to be calculated with a bandwidth of $f_B^{'}$ and N_D lines (this means you have $\frac{N_D}{2}$ lines in the spectrum). The sampling rate f_T is given.

From the bandwidth $f_B^{'}$ we can find the re-sampling frequency $f_T^{'}$, according to the Sampling Theorem, as

$$f_T^{'} \geq 2 f_B^{'}.$$

Since the AAF - filter has a limited slope, we choose as the re-sampling frequency

$$f_T^{'} = 4 f_B^{'}$$

and compute an FFT which is twice as large, while not displaying the upper spectral lines.

$$N_D^{'} = 2 N_D$$

We use a 16th order Butterworth filter. The cutoff frequency is set to $1.2 * f_B^{'}$.

Thus we need

$$N_Z = N_D^{'} \frac{f_T}{f_T^{'}}$$
$$= 2 N_D \frac{f_T}{4 f_B^{'}}$$
$$= N_D \frac{f_T}{2 f_B}$$

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data points in order to be able to calculate the spectrum with the desired bandwidth and number of lines.

Order analysis, on the one hand, and the calculation of the RPM-spectrum on the other hand each require a particular number N_Z of data points in the time-signal.

$$N_{ZO} = \frac{1}{\Delta O}\frac{60}{n(t)} f_T$$ order spectrum

$$N_{ZD} = N_D \frac{f_T}{2 f_B^{'}}$$ RPM-spectrum

Performing an example analysis based on particular values, we obtain the following plot of the number of data points required for the order spectrum and for the RPM-spectrum, respectively.

ΔO = 1/16
f_T = 10 kHz
$f_B^{'}$ = 2 kHz
N_D = 4096
$n(t)$ = 600 ... 6000 RPM

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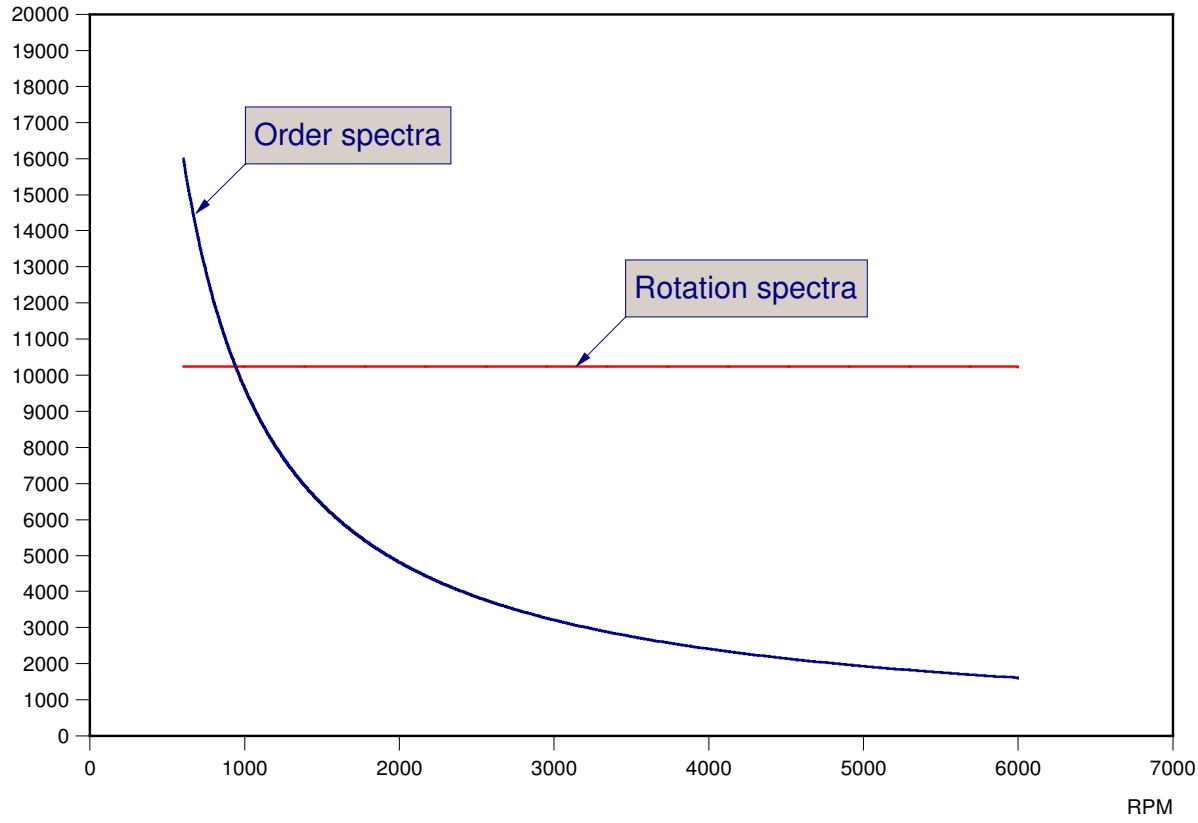

Fig. 193: Data points required for calculating different spectra

At low RPM values, the number of data points required for order analysis is greater than for the RPM-spectrum.

From the RPM value n_0 on, the number of data points required for the RPM-spectrum is greater than for the order spectrum.

$$n_0 = \frac{60}{\Delta O} \frac{2 f_B^{'}}{N_D}$$

The example treated yields $n_0 = 937{,}5$.

So, which basis for calculating the minimum required number of data points depends on the RPM value.

23.3 How to configure the Order Analyzer

imc WAVE's Order Analyzer provides a user interface adapted to make order analysis easy.

The Order Analyzer has two dialogs:

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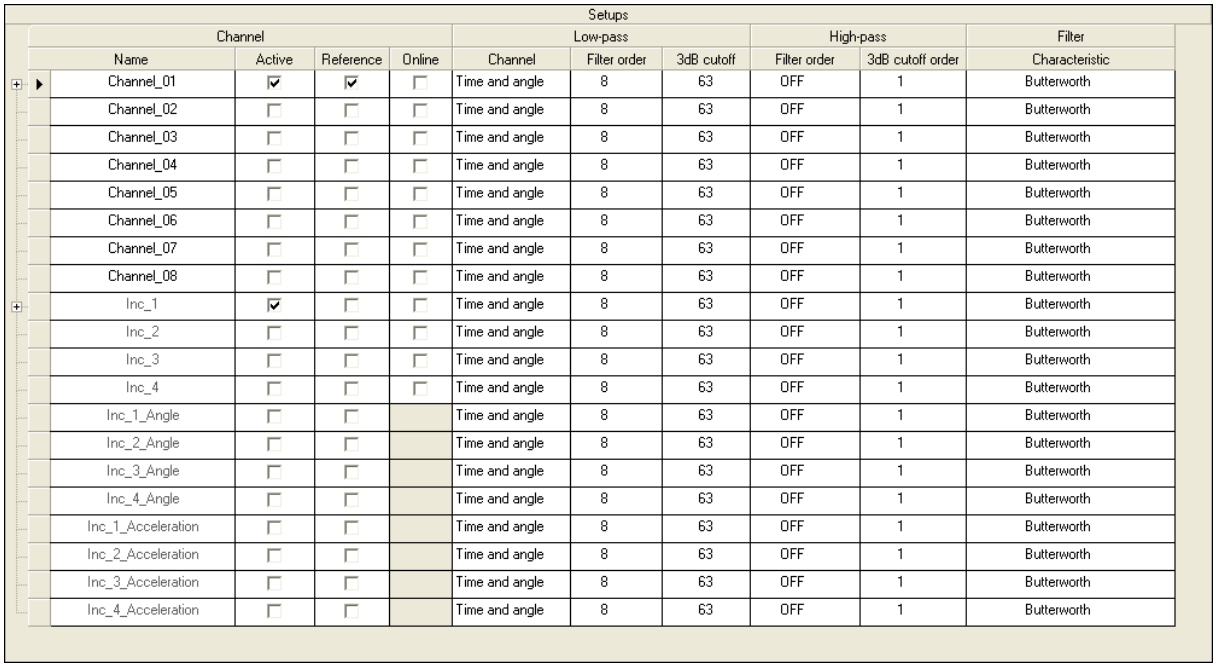
1. for definition of the input and output channels, with their parameters,
2. for configuration of the order analysis and related quantities.

In addition to the order analysis, another configurable spectrum analysis, the so-called RPM-spectrum, is determined. imc WAVE returns the input quantity data both in the time domain and in the rotation angel domain, as well as their respective spectra.

To configure the Order Analyzer, select the entry "Order Analyzer" in the Project Explorer.



Setups

Channel				Low-pass			High-pass		Filter
Name	Active	Reference	Online	Channel	Filter order	3dB cutoff	Filter order	3dB cutoff order	Characteristic
Channel_01	☑	☑	☐	Time and angle	8	63	OFF	1	Butterworth
Channel_02	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Channel_03	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Channel_04	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Channel_05	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Channel_06	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Channel_07	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Channel_08	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Inc_1	☑	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Inc_2	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Inc_3	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Inc_4	☐	☐	☐	Time and angle	8	63	OFF	1	Butterworth
Inc_1_Angle	☐	☐		Time and angle	8	63	OFF	1	Butterworth
Inc_2_Angle	☐	☐		Time and angle	8	63	OFF	1	Butterworth
Inc_3_Angle	☐	☐		Time and angle	8	63	OFF	1	Butterworth
Inc_4_Angle	☐	☐		Time and angle	8	63	OFF	1	Butterworth
Inc_1_Acceleration	☐	☐		Time and angle	8	63	OFF	1	Butterworth
Inc_2_Acceleration	☐	☐		Time and angle	8	63	OFF	1	Butterworth
Inc_3_Acceleration	☐	☐		Time and angle	8	63	OFF	1	Butterworth
Inc_4_Acceleration	☐	☐		Time and angle	8	63	OFF	1	Butterworth

Fig. 194: Order Analysis settings interface

Then a table appears which shows the system's input channels. Individual channels can be activated by placing a check mark in the "Active" checkbox.
Filter settings for the order analysis can also be made in this table. You can set the order of a low- and high-pass filter, as well as the order of the 3dB-corner. The corner order corresponds to the filter's corner frequency, but is stated in the order domain, so that the filtering is performed in each RPM-class with different but adapted cutoff frequencies.
Additionally, you have the option of selecting the filter's characteristics. The following characteristics are available:

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- Butterworth
- Bessel
- Chebysheff
- critical damping

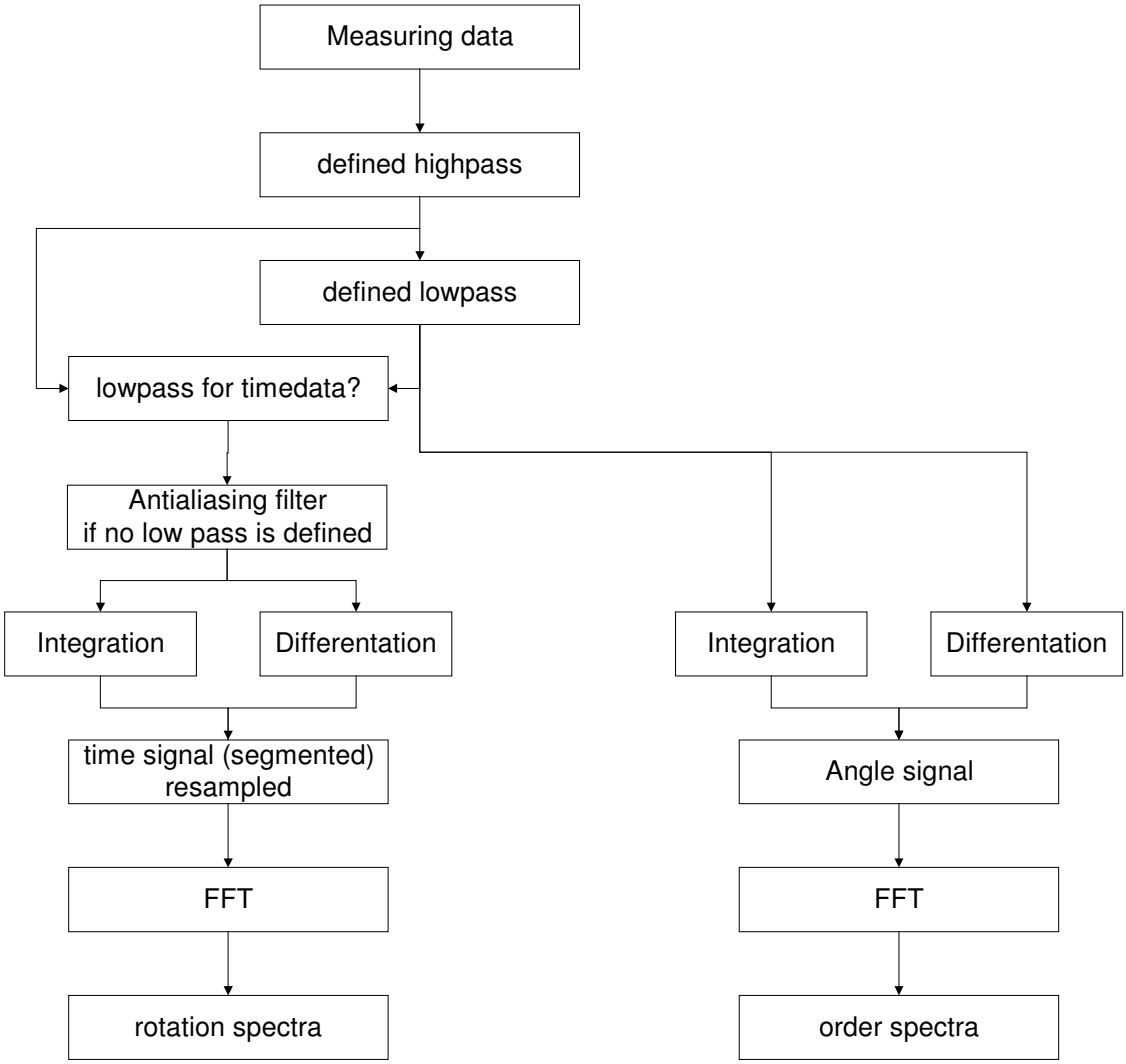

Fig. 195: Flowchart of output channel signal calculation

After activating the channels, you can decide whether to have them processed on-line and whether to use one channel as the reference channel for calculating the transfer functions. Both settings only apply to one channel.

Calculating the high-pass filter is only performed on the PC once the measurement is completed. On-line calculation of the high-pass filter on the measurement system's DSP is not available.

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The order analyzer's inputs are analog measurement channels and incremental encoder channels. In the operating mode "Impulse instant", the RPM-values, rotation angle and rotational acceleration are automatically computed from the incremental encoder channels. In the incremental encoder inputs' other operating modes, these computed channels are mostly not useful. The computed channels come with the same settings options as the measured channels and can be used as reference channels for determining transfer functions.

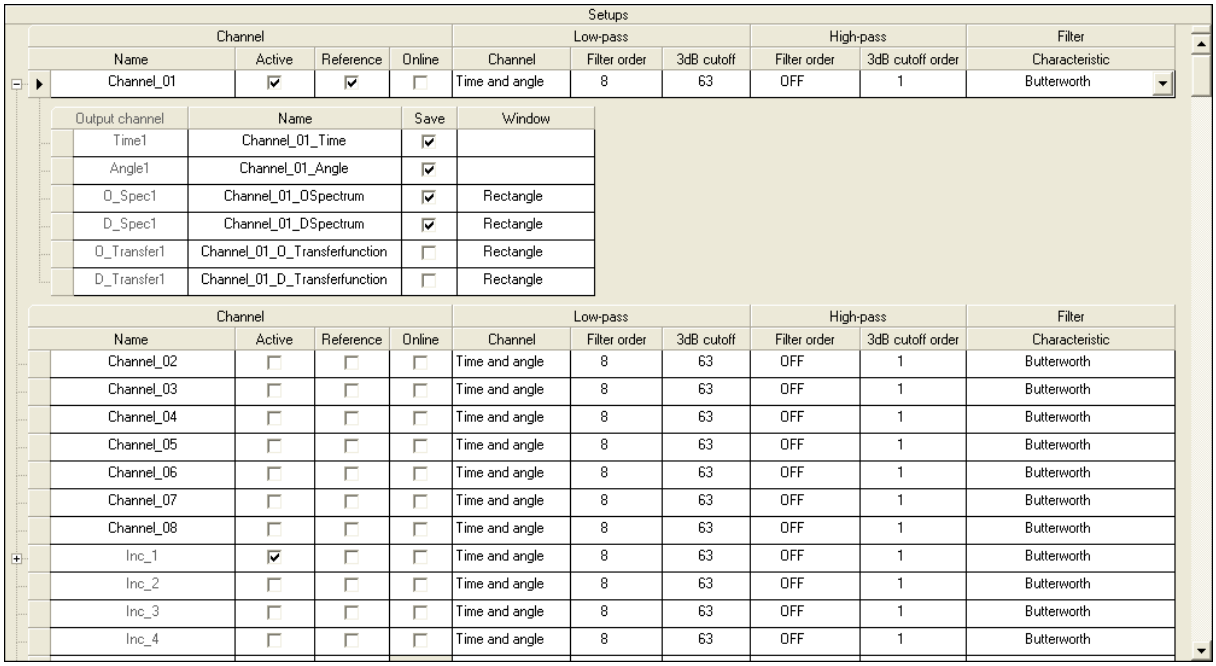

Fig. 196: Order Analyzer settings interface

Once you have activated the right channel and made all appropriate settings, you can view the analyzer's output channels by clicking on the little "+"-sign at the front of the row in the table.

The following output channels are provided:

- **Time data**
  the input signal as it enters the analyzer's input terminal.
- **Angle data**
  the input signal transformed into the rotation angle domain.
- **Order spectrum**
  the FFT transform of the angle data. You must select as the parameter the window function used to weight the angle-based signal before FFT transformation. In order analysis, a rectangular window is usual.
  The length and resolution are determined from the settings in the Order Analyzer's Options dialog.

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- **RPM-spectrum**
  is the FFT transform of the time-based data. You must select as the parameter the window function used to weight the time-based signal before FFT transformation.
  The length and resolution are again determined from the settings in the Options dialog.
- **RPM-spectrum frequency response function**
  The RPM-spectrum's frequency response function is determined from the active channel's time signal and that of the reference channel. The settings options are the same as for the RPM-spectrum.
- **Order spectrum frequency response function**
  The order spectrum's frequency response function is determined from the active channel's angle signal and that of the reference channel. The settings options are the same as for the order spectrum.

For a more simple way to configure the input channels, you can use the menu item "Adopt active channel's settings for all channels ". By this means, you copy the configuration of the channel currently active to all other active channels and save yourself the trouble of making all the same entries again. This is especially advantageous for multi-channel measurements.

To save space on your computer's hard drive, you can limit data saving to fundamental data (time- and angle plot). To do this, select the menu item "Save only basis data". You can reconstruct any derived data from these fundamental data at any time. If you have already had an analysis carried out and some derivative data have already been saved along with the fundamental data, you can use the menu item "Delete derived data" to clear the derivative data from the hard drive.

23.4 What are the different classification types available?

imc WAVE's order tracking analyzer offers three different classification types.

1. **Online classification**
   The data are already divided into classes of the reference quantity during data acquisition.

2. **Offline classification**
   The data are only divided into classes of the reference quantity at the end of the measurement.

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3. **No classification**
   The data are never divided into classes of the reference quantity.

The procedures differ in terms of their data throughput and of their memory demands.

23.4.1 The online classification procedure

In this procedure, the data are classified according to the reference quantity during a running measurement. If an reference quantity class is recognized which has not yet been measured and which is relevant for the class filling style you selected, capture of the input quantity data is started and, if successful, the data are saved. Then the measurement is stopped and the system waits for the signal to enter a class not yet measured.

This procedure significantly reduces the volume of data measured, since no data lying between the reference quantity's classes are recorded. Due to the amunt of time required, however, the throughput of measured data is less than for the other two evaluation styles.

Online classification is activated in the Options dialog by selecting the entry "Online" from the pop-down list "Classification".

23.4.2 The offline classification procedure

This procedure continuously records all measured data from the start of the measurement up until it is stopped manually, and does not carry out classification according to the reference quantity during the measurement's run. Classification is only performed after the measurement stops. All data measured are saved, so that they are available for analysis.

Offline classification is activated in the Options dialog by selecting the entry "Offline" from the pop-down list "Classification".

23.4.3 The "no" classification procedure

This procedure basically works in the same way as offline classification, except that no classification is performed at the end of data acquisition. All relevant measured data are saved on the control PC. Analysis can still be performed later. The procedure can be used for cases where multiple measurements are performed in rapid succession and any time-consuming analysis is not an option.

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The omission of classification is activated in the Options dialog by selecting the entry “None” from the pop-down list “Classification”.

It is possible to make measurements in a single project with a variety of acquisition modes. In the background, imc WAVE administers the settings and performs the computations accordingly.

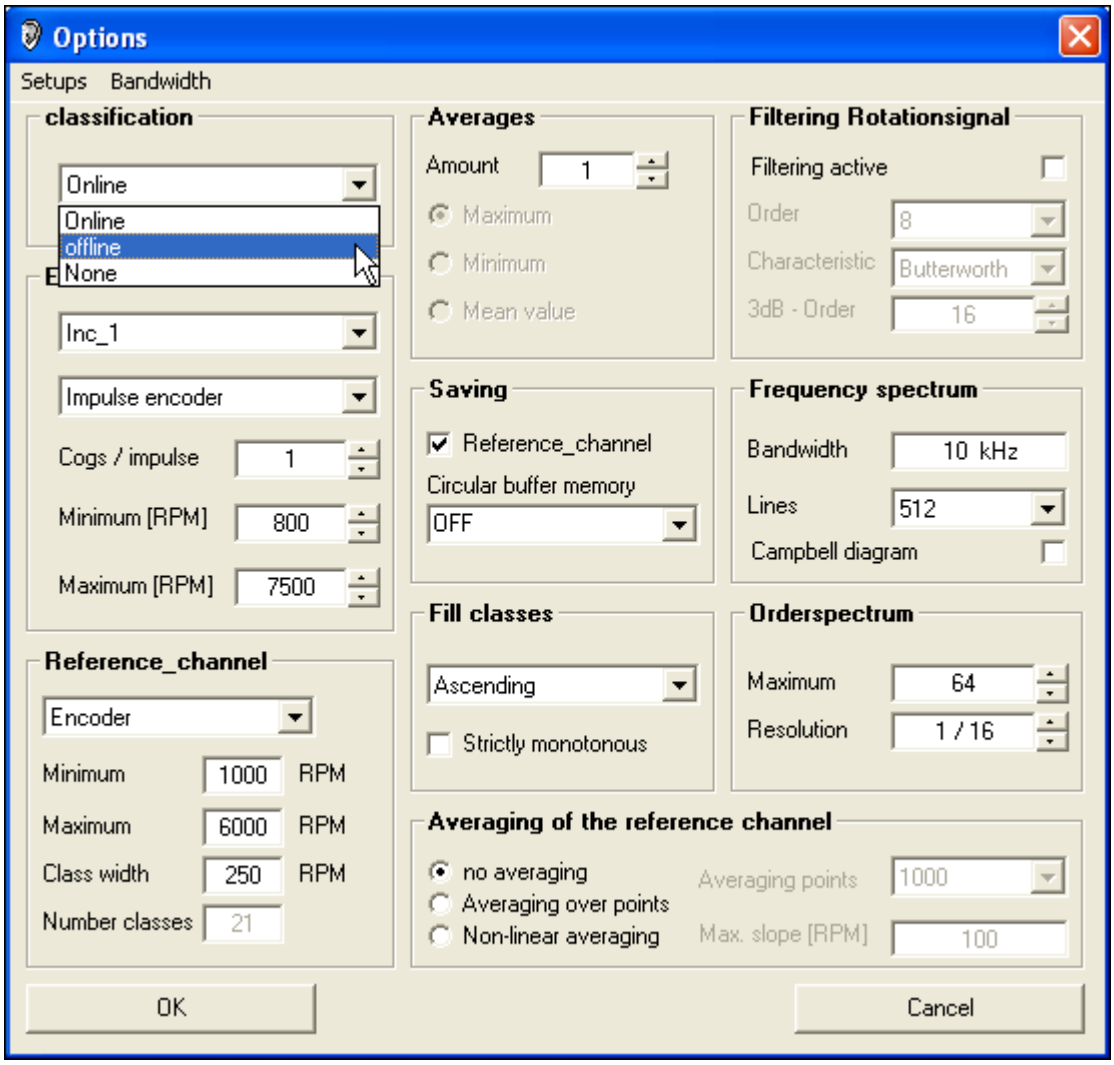

Fig. 197: Activating the offline classification measurement mode

23.4.4 Evaluation of the different analysis types

For analysis of the measurement, a variety of modes are available.

In imc WAVE, analysis is always organized in two stages:

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1. **Classification of the raw data**
   During data capture, the time-domain data of the reference quantity, of the revolution speed and of the other quantities are recorded. In online classification, these measurement quantities are divided into o classes of the reference quantity directly in the measurement system, and only the relevant segments of the time-domain data sets are transferred. This results in a reduction of data volume transferred.
   With offline classification, this procedure is performed offline in the PC. In imc WAVE, this is known as ThrougPut analysis. For the procedures "Offline" and "None", you can always activate this analysis with the button or the menu item "Order tracking analyzer – ThroughPut analysis". Each time that it is carried out, a new measurement folder is created and all primary data copied.

   You can carry out these calculations as long as the primary data are still available. The primary data can be deleted from the project by selecting the menu item "Delete primary data ThroughPut".

2. **Calculating the derived data**
   This calculation of the derived data follows the classification. Using the classified primary data, the derived data are next generated. These include:

   - RPM-spectra
   - Order spectra
   - Transfer functions in the RPM- and order domains

   In imc WAVE, this procedure is referred to as "Perform evaluation". To activate it, use the button or the menu item "Order tracking analyzer – Perform evaluation".

   This computation can then be performed manually for all three classification types. No new measurement folder is generated, instead, the last analysis is always overwritten.

   With the classification type "None", the ThroughPut data must first be evaluated before the calculation is performed, otherwise an error message will be posted.

23.5 What are virtual channels in the Order Tracking Analyzer?

Besides the system's physical input channels, it is also possible to obtain virtual input channels which are derived from the physical input channels.

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Such new channels can be generated by applying multiplication and addition to the physical input channels. The virtual channels are generated offline for the time and angle domains.

To generate a virtual channel, select from the "Order tracking analyzer" menu the item "Create virtual channel". The following dialog then appears.

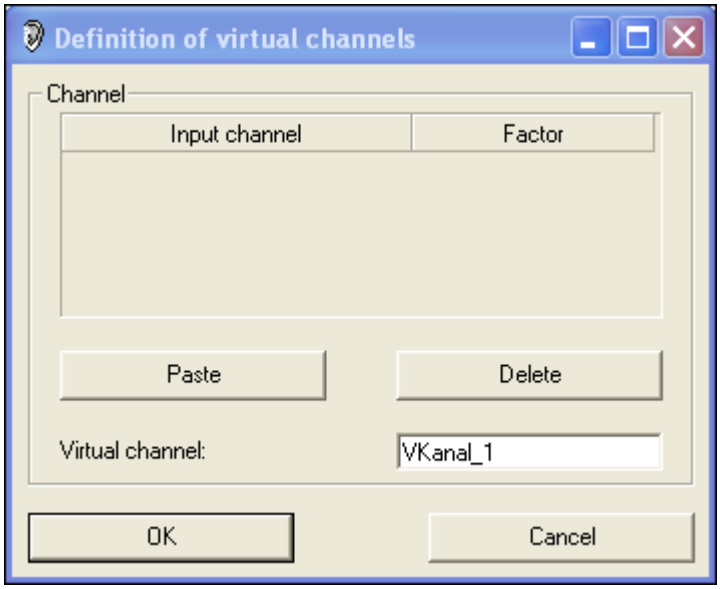

Fig. 198: Dialog for generating new virtual channels

When you click on the button "Paste", new rows are appended to the table. In each of these rows is a combobox which enables you to choose from among the available physical input channels, and another control in which you can set a factor to apply to the physical channel selected. All the channels are multiplied with this factor, and the sum of the results is taken. The calculation is applied to both the time and angle domains. For instance, to subtract one physical channel from another one, add two new rows to the table and assign a factor of 1 to the first input channel and the factor –1 to the second. This will cause the difference between the channels to be determined. You can enter a name for the virtual channel in the input box "Virtual channel". In our example, if you name the virtual channel "VKanal_1", and the physical input channels are two incremental encoder channels, the definitions dialog would appear as shown below.

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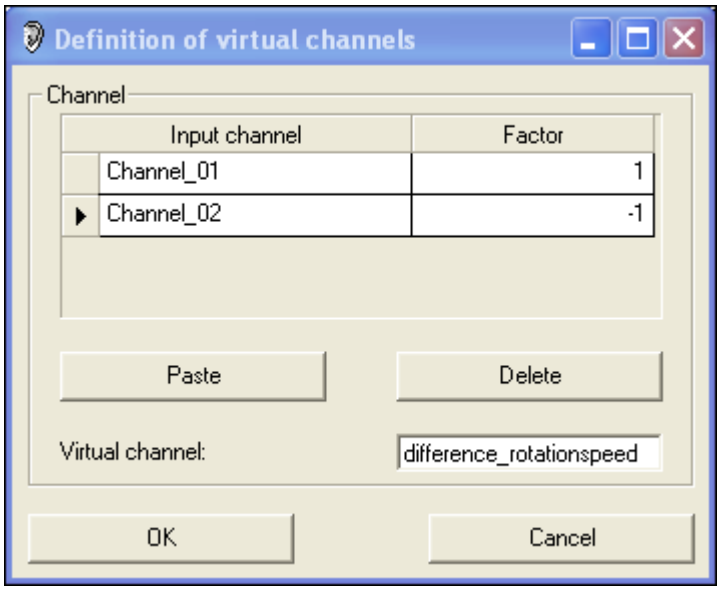

Fig. 199: Dialog for creating a virtual channel form two incremental encoder channels and for determining the difference

The main menu additionally contains items for editing and deleting a virtual channel. Select the row in the Order Tracking Analyzer's main table which corresponds to the desired channel and then select the menu item corresponding to the desired action.

23.6 What optional parameters exist?

To continue with the configuration of the Order Analyzer, select the entry "Options" under the heading "Order Analyzer" in the Project Explorer.

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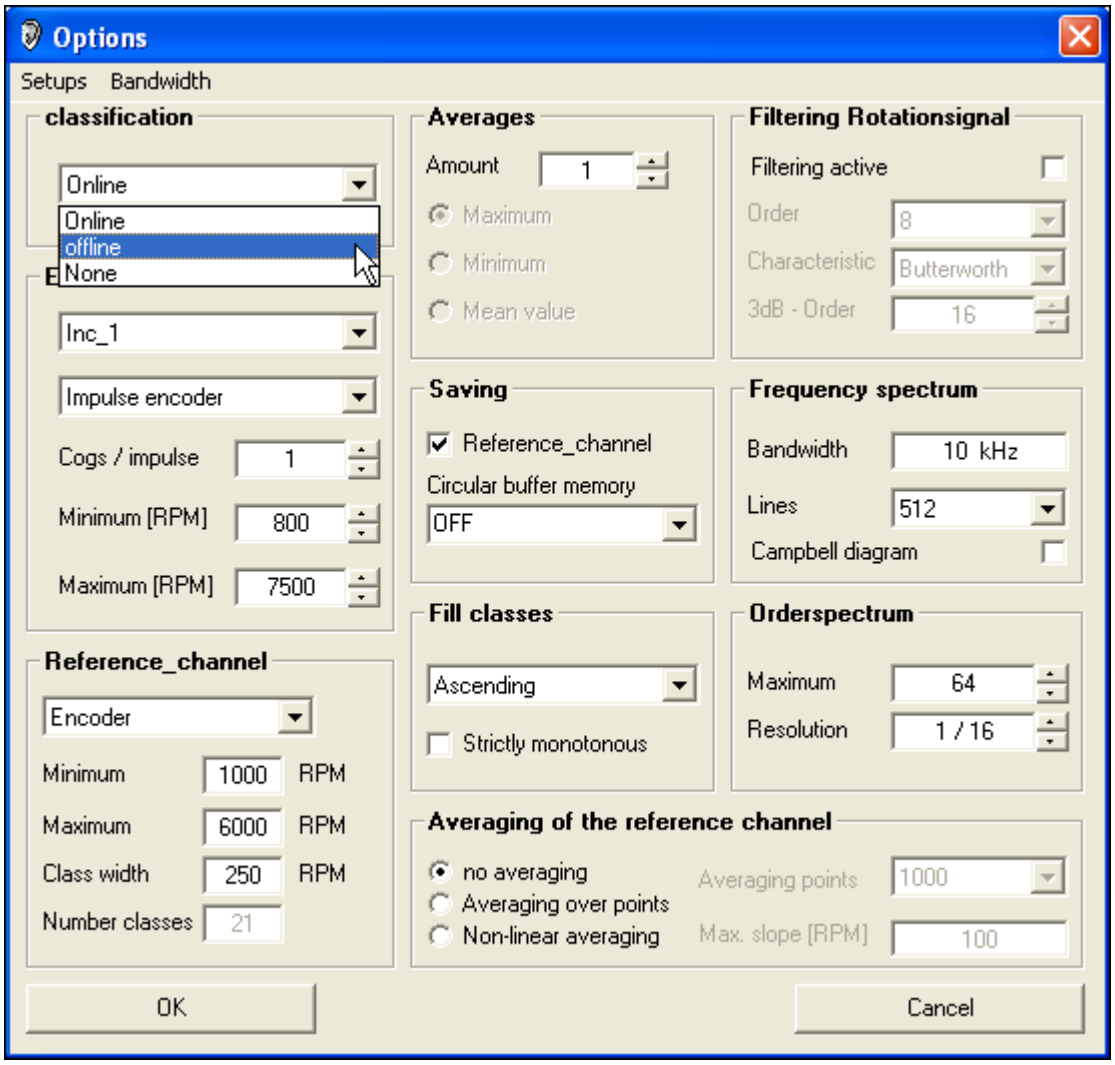

Fig. 200: Options dialog for configuring measurement of the order

Here, you can configure the order-tracking analysis according to your requirements.

No matter what reference quantity is selected, an RPM-signal is always required for tracking analysis to transform time-based data to the angle domain.

The following parameters can be set:

Encoder
Definition of the encoder

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- **Selection of the RPM-input**
  Here you can select the physical input of the measurement device to which to connect your RPM-signal.

- **Selection of incremental encoder type**
  Here you can select the type of incremental encoder connected to your device. The available types are incremental encoder, Cogwheel (1 missing cog) and Cogwheel (2 missing cogs).

- **Cogs/Impulses**
  Here, you can set the number of impulses or number of cogs per revolution. If you have selected an encoder with one or two missing cogs, enter here the complete cog count, including the missing ones; e.g., if the whole wheel has 60 cogs though two were removed for synchronization purposes, enter 60 cogs.

- **Minimum**
  Set the minimum RPM-value here, if the encoder is not to be used as the reference quantity for the order analysis.

- **Maximum**
  Set the maximum RPM-value here, if the encoder is not to be used as the reference quantity for the order analysis.

The hardware settings for the incremental encoders are made in the Additional Channels dialog. There, you can make the filter settings, for instance, or set the channels' switching thresholds or hysteresis. The encoder channel is always assumed to be an incremental encoder channel with the setting "Impulse instant". Thus, in the list of encoders, only such channels appear whose setting is "Impulse instant". In this setting, the RPM-value is measured at a sampling frequency of 32MHz. This makes highly precise measurement of angle possible.

If the encoder signal is disturbed, you can specify band limits for RPM-filtering, in order to prevent a large portion of the disturbance from affecting the processing of the angle signals. The filtering is activated for the encoder signal by means of the option button "Filtering active". The available parameters are the order, the characteristic curve and the filter's 3dB cutoff order.

Reference channel

Select which reference channel you wish to carry out the order analysis with. There are two basic options available:

1. Encoder reference quantity
   The incremental encoder channel specified under Encoder is used as the reference channel for the order analysis.

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If the order analysis is to be carried out using more than one device, the only available choice for the reference quantity is the RPMs.

2. Reference quantity: analog input channel
   Here you can select one of your analog input channels as the reference channel.

The reference input is selected in the selection list under the heading "Reference input".

Under the heading "Saving", you can determine whether the reference quantity is saved at the end of the measurement and whether the reference quantity is displayed in circular buffer memory of specifiable length. These settings are useful for measurements in which the reference quantity must be observed over long periods of time. This gives you the ability to not save the reference quantity at the end of the measurement, and during the measurement, only to display it over the specified range of time. All measured data older than the circular buffer duration set are automatically discarded by imc WAVE and no longer displayed. Consequently, with this setting, at the end of the measurement only measured data of the reference quantity not older than the circular buffer time set remain.

Average of the reference quantity

For reference quantities which are very noisy or subject to strong interference, imc WAVE offers signal smoothing under the heading "Filtering the reference quantity". Two different techniques are available for this purpose.

- Averaging over points
  In this setting, the reference quantity is averaged over a selected number of averaging points. The averaging is carried out using a moving rectangular window.

- Non-linear averaging
  With non-linear averaging, the signal's maximum slope is limited. In practice, it is possible to estimate the maximum change in the reference quantity based on, for instance, the given mechanical constraints, and to achieve good results despite very noisy reference quantities by means of this non-linear averaging method.

This reference input is next divided into classes; you select a minimum and a maximum, a class width (bin spacing) and this results in a certain amount of classes. Ultimately, a spectrum is returned for each class into

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which the reference input signal enters. Thus the bin spacing determines the resolution of the spectra.

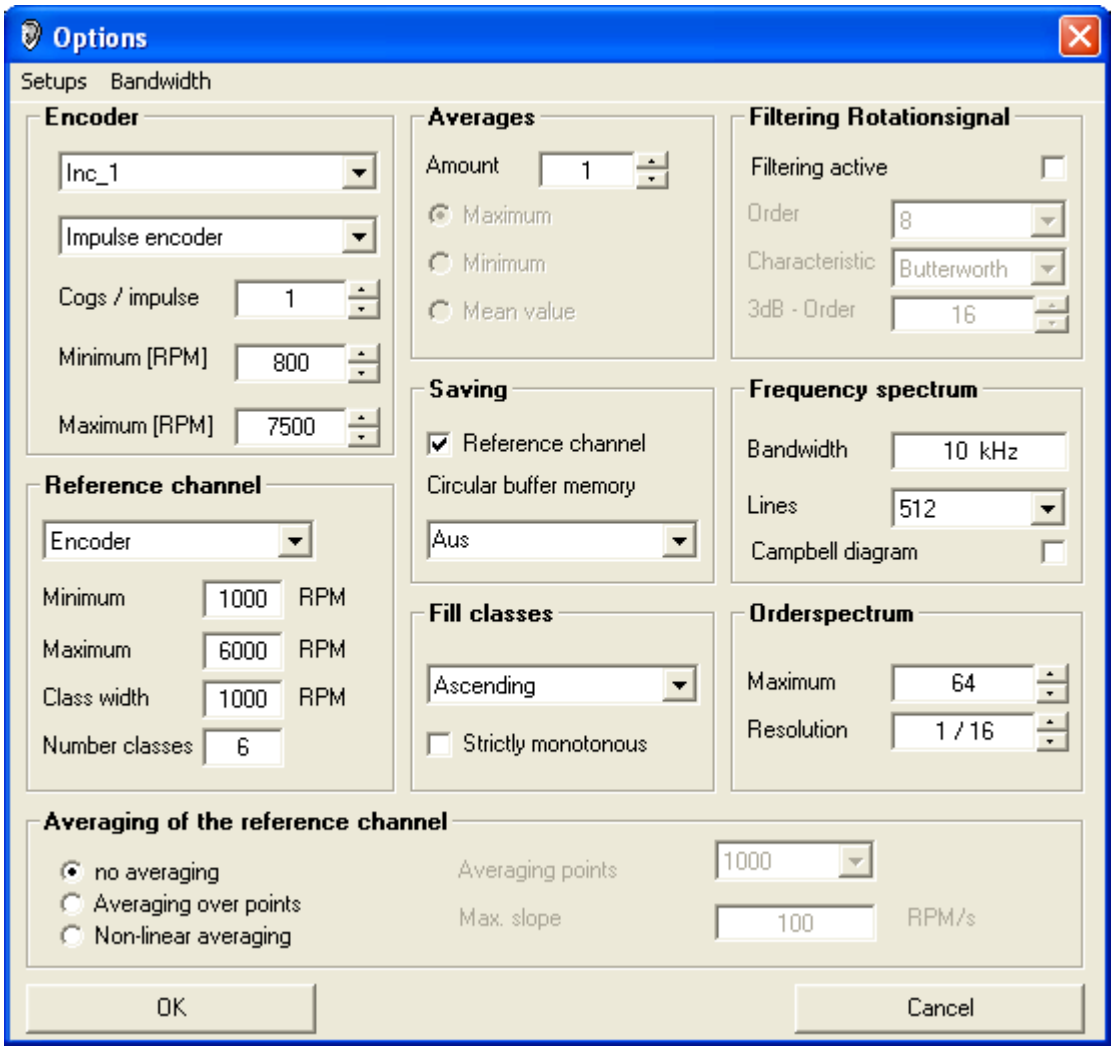

Fig. 201: Options dialog for configuration of order measurement

After the reference input and rotation speed input have been defined, it is time to set how the reference input's classes are filled.

Usually, a run-up does not proceed linearly from the lowest to the highest rotation speed. Thus it can happen that the rotation speed fluctuates strongly and even falls into a lower class even during a run-up. However, for some measurement tasks it is important to only record the signal progressing through a class not below the last class in which it was measured.

For this purpose, you can set the way the classes are filled. The options available are:

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- **Ascending**
  Here, only the same class or those above the last class are filled.

- **Descending**
  Here, only the same class or those below the last class are filled.

- **Always**
  In this case, measurement is performed no matter in what class the last measurement took place.

- **Manual**
  With this setting you can override the automated data acquisition and start data capture by pressing the Start-button in the interface. But this manual triggering still takes account of the reference quantity's class structure. If enough data are present within a single class, no further measurements are run in that class. Display of the data in the color map or waterfall diagram makes use of the reference quantity. If multiple measurements are taken within a single class, these averages are averaged again in the spectral representation.

- **Free Measurement**
  In free measurement, the reference quantity settings aren't taken into account. Measurement starts whenever the Start button is pushed. Display is not based on the reference quantity but on the measurements' incremental count.

- **Free Run**
  With this setting, data acquisition for the order analysis is automatically started and continues until the Stop button is pressed. This applies irrespective of any class partitioning defined.

For the options "Ascending" and "Descending", there is the additional available control "Strictly monotonous".

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An example to illustrate:

> Suppose you define 100 classes starting at 1000 RPM, with a class width of 10 RPM and "Increasing" class filling. Measurement starts in the 1000 RPM class, then the rotation speed signal jumps to 1040 RPM, so that 3 classes were jumped over. The next measurement is performed in the class which includes the rotation speed 1040 RPM. After that, the signal falls back into the 1010 RPM class; but now, no measurement takes place, since the class filling method set is "Increasing". The rotation speed rises again and reaches the 1030 RPM class. This time a measurement starts, since this class is higher than the last one.
>
> If you had also activated the option "Strictly monotonous", the measurement in the 1030 RPM class would also not take place, since in this case measurements are only taken in classes at least as high as the highest class to date, and we already in the 1040 RPM class.

The same applies to the option "Decreasing". Here, measurement is performed in a class at least as low as the last class in which measurement was performed.

Measurements

Next you can set the amount of measurements to be taken in each class. If you set more than 1, you must also set how the individual measurements are summarized for their class.

The available choices are:

1. **Maximum**
   The maximum value for each order and RPM-line is determined.

2. **Minimum**
   The minimum value for each order and RPM-line is determined.

3. **Mean value**
   The arithmetic mean of the values for each order and RPM-line is computed.

At the end, you obtain one order and RPM-spectrum per class, which is derived from the class's multiple individual measurements according to the method selected by the user.

Next, you must select the actual parameters for the RPM- and order spectrum.

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Rpm-spectrum parameters:

1. **Bandwidth B**
   This determines the frequency range in which the RPM-spectrum is calculated.

2. **Line count N**
   The amount of lines specified here is used to generate the FFT.

The FFT's frequency resolution is computed from these two quantities as:

$$\Delta f = \frac{B}{N}$$

Order spectrum parameters

1. **Maximum O_{MAX}**
   Here you define the maximum order in the order spectrum. The order spectrum is up to this order is computed.

2. **Resolution ΔO**
   Defining the resolution determines the number of intermediate lines between two whole orders in the order spectrum.

23.7 How to perform a measurement with the Order Analyzer

Once we have configured a measurement, we can carry out measurements.
Before conducting a measurement, the corresponding measurement setup must be made available. Connect the appropriate sensors to the measurement device and connect the measurement device to the computer. For assistance in this, refer to the included imc CRONOS PL user's manual.

Once the necessary connections have been made, you can initialize measurement by pressing the button , and start measurement using the button . The accumulating data can be viewed in a screen. Toward that end, create a screen which displays the necessary measured data (on this topic, see the chapter on creating curve windows and screens).

Upon the measurement's conclusion, the data can be saved to the disk automatically (on this topic, see the chapter "Data" on the available settings options).

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24 The Personal Analyzer

imc WAVE provides a variety of analyzers for performing measurements. These include:

- Structure Analyzer
- Sound Power Analyzer
- Order Analyzer
- Spectrum Analyzer
- etc.

In contrast to the elements of this list, the Personal Analyzer is special in that it can be adapted to meet the requirements of the user's own particular measurement and analysis tasks, instead of forcing the user's work procedures to be adapted to a fixed structure.

24.1 Introduction

The Personal Analyzer works on the basis of imc FAMOS. It requires a functioning FAMOS installation of Version 3.2 or higher.

The entire imc WAVE interface is available along with its accustomed convenience of use.

Unlike the other analyzers, the Personal Analyzer's operating interface doesn't feature a permanent set of output channels. Instead, the user is able to use imc FAMOS sequences to personally define output channels.

24.2 How to create new output channels

Start the Personal Analyzer interface from the Project Explorer by double-clicking on the entry "Personal Analyzer".

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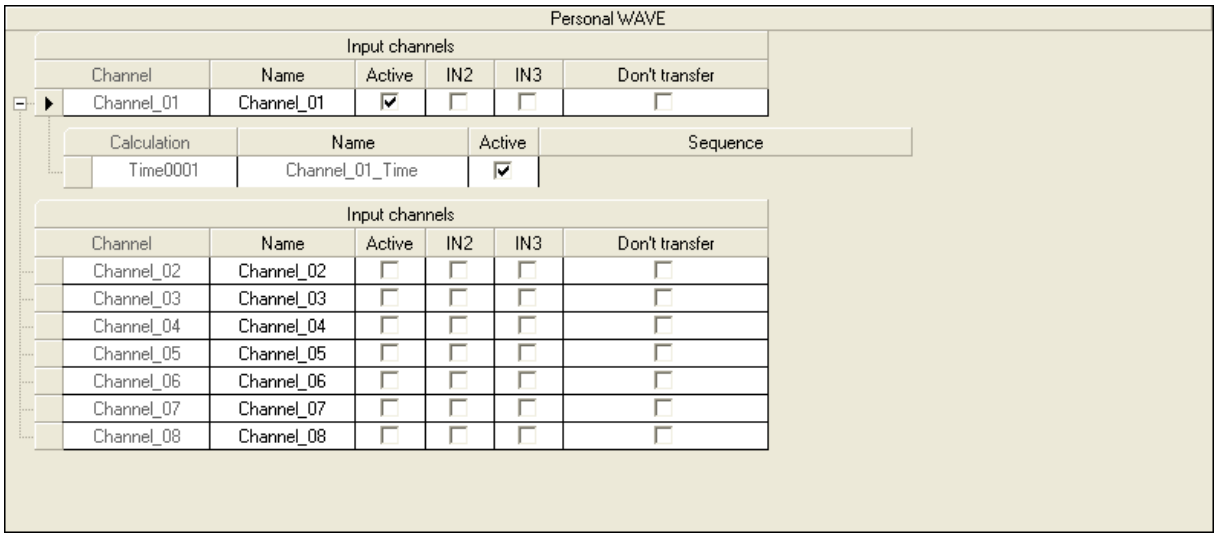

Fig. 202: The Personal Analyzer's user interface

If you set the first channel as active and view its output channels, you see that there is only the time-domain channel. At this point, you can add your own output channels. To do this, right-click the mouse over the dialog to open the context menu and select the item

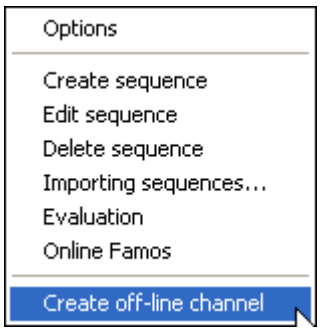

Fig. 203: Personal Analyzer context menu

"Create offline channel" or select the corresponding item from the main window menu "Personal Analyzer".

Next, you will be prompted to enter a name for the new output channel. If you enter "evaluated", for instance, a new output channel with the name Channel_01_evaluated will be created. Then, you must assign a calculation algorithm to the new channel. To do this, select an appropriate sequence form the "Sequences" list. Later we will discuss how to create your own calculation sequences. For now, select, as an example, the calculation sequence "Whole body vibration".

Then the dialog will look like this:

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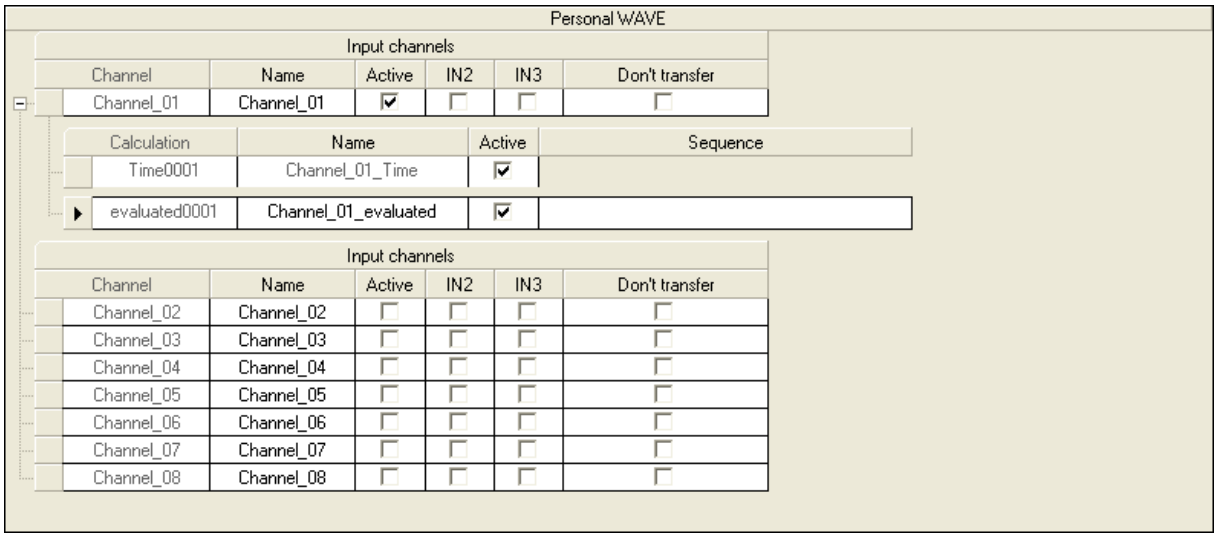

Fig. 204: The user's interface of the Personal Analyzer with a new output channel

Besides being able to activate the channels, you have the ability to define the input channels as Reference Quantity 1 or Reference Quantity 2. These reference quantities are passed to the calculational sequences along with the input channels, enabling you to perform calculations which depend on more than one input quantity (e.g. calculation of transfer functions or order tracking analyses which depend on the input quantity and the RPMs).

24.3 How to create a new FAMOS Sequence

The sequences for creating output channels are run subsequent to data acquisition. For this purpose, the input channel and any reference channels defined are transferred to imc FAMOS, and the desired sequence is run.

If you wish to define your own sequence, right-click the mouse over the Personal Analyzer dialog and select from the context menu which then appears the item "Create sequence", or select the corresponding item from the "Personal Analyzer" menu in the main window.

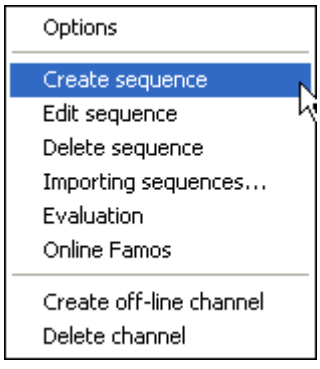

Fig. 205: Creating a sequence for calculating an output channel

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In the dialog which then appears, enter a name for the sequence. Once this is done, the program creates a sequence as instructed and starts imc FAMOS. You then have imc FAMOS' full functionality at your disposal and can carry out the calculation desired. For details on programming with imc FAMOS and creating sequences, refer to the imc FAMOS user's manual.

The sequence you created has input and output quantities. These quantities are to be named as follows:

Input quantity:	IN1
Reference Quantity 1:	IN2
Reference Quantity 2:	IN3
Output quantity:	OUT1

imc WAVE automatically transfers channels with these names to imc FAMOS when you run a sequence.

Once you have created the sequence, simply save it under its designated name in the default folder, so that imc WAVE can find it again later.

Besides for the creation of sequences, there are menu items for editing and deleting sequences.

Once you have carried out a measurement, you can also run the sequences manually at any time. To do this, select the menu item "Evaluation".

24.4 Optional Personal Analyzer settings

The Personal Analyzer's optional settings enable you to adapt it to your personal requirements.

The following settings options are available:

Off-line calculation

- Help text in FAMOS sequences
  If you activate this button, the templates for the imc FAMOS sequences are provided with help texts. Then you will always have information available on the names of the input and output channels.

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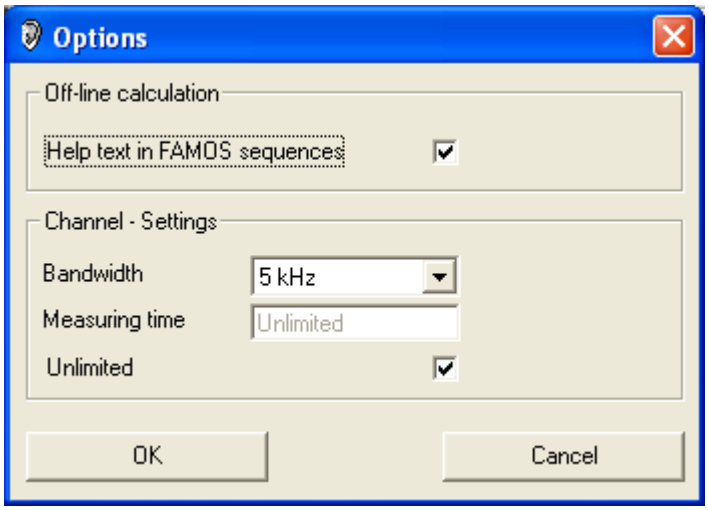

Fig. 206: Making optional Personal Analyzer settings

Channel settings

- Bandwidth
  Here you can set the bandwidth for data acquisition. Select one of the entries in the list.

- Measuring time
  Here you can set how long the data are to be captured. You can only make a setting under this heading of the option button below it is not active.

- Unlimited
  If this option button is activated, the data are recorded without cease until the measurement is stopped manually by a stop command.

24.5 The Personal Analyzer working with automated evaluation

In conjunction with automated evaluation, the Personal Analyzer can be used to obtain a complete data evaluation all the way to composition of a report.

As an example, regard the calculation of Hand-Arm and whole-body vibration as per EN1032.

This standard describes a procedure for measuring vibration emission values for moving machinery.

The standard prescribes a number of different evaluation filters for the various directions and types of vibration.

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Hand-arm vibration
x-direction Filter function Wh
y-direction Filter function Wh
z-direction Filter function Wh

Whole body vibrations
x-direction Filter function Wd
y-direction Filter function Wd
z-direction Filter function Wk

The filter functions are defined in the standards EN ISO 5349-1 and ISO 2631-1.

These filter functions are defined with the help of the Personal Analyzer's sequences.

If the data are captured using 6 accelerometers (three each for both hand-arm vibrations and whole body vibrations) and the corresponding filter functions were realized by means of imc FAMOS sequences, then the Personal Analyzer's interface will appear as shown below:

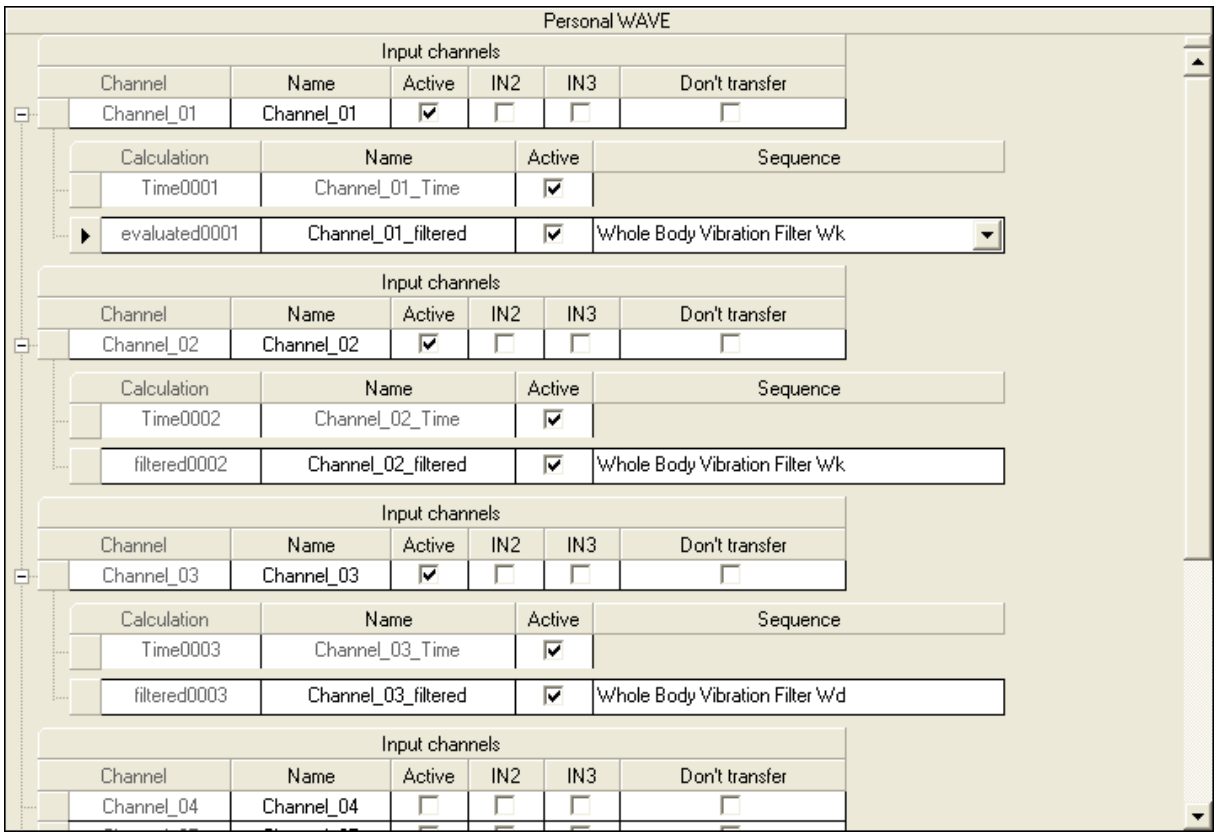

Fig. 207: Setting the Personal Analyzer for determining the evaluated hand-arm and whole-body vibration signals

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The Personal Analyzer's associated output signals are indicated under the heading "Name" and the corresponding sequence appears in the same table row under "Sequence". In consequence, the desired filtered time functions are calculated at the end of the measurement.

In the Options dialog, set the bandwidth to 5 kHz and the measuring time to 15 seconds to define the data acquisition.

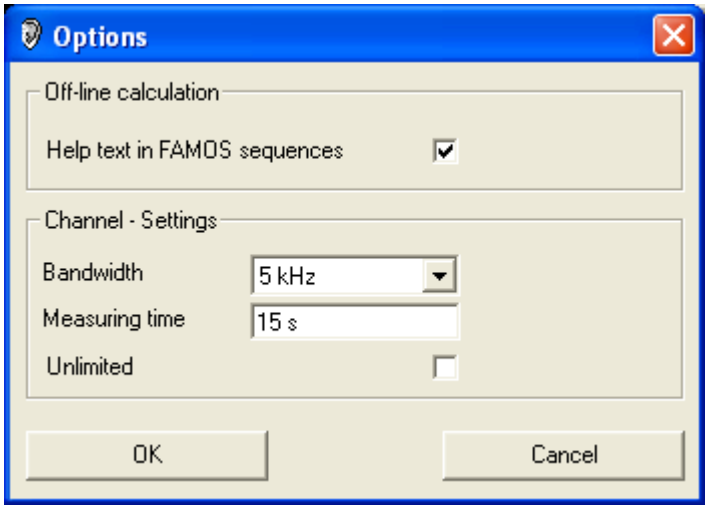

Fig. 208: Setting the bandwidth and measuring time

Subsequent standard-compliant calculations are carried out by means of "Automatic evaluation".

The program for the automatic evaluation is represented in the dialog shown below.

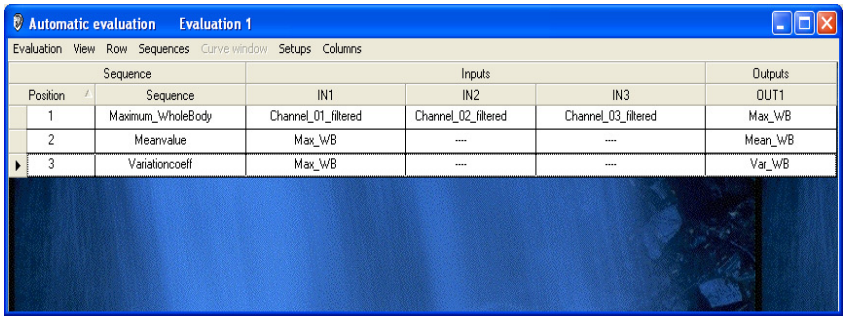

Fig. 209: Defining the automatic evaluation program

The following sequences are defined:

- **Maximum_WholeBody**
  Calculation of the maximum RMS-value within the measuring time according to the formula $a_{Max} = \max\{1.4 \times a_x; 1.4 \times a_y; a_z\}$

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- **Mean value**
  Formation of an overall mean value from the mean values of the individual sweeps (triggered runs)
- **Variation coefficient**
  Computation of the variation coefficient for the individual sweeps

The sequences are written in such a way that they can be applied to multiple sweeps (triggered runs) or to just one. If there is only one sweep, then no mean value is calculated. With multiple sweeps, you can calculate the mean values and variances of the sums or maxima of the different component directions. Such calculations can be performed either for the Hand-Arm or Whole-body vibrations.

If you work with triggers, it may make sense to define a manual start to the measurement as a trigger event. In the trigger dialog accessed via the "Trigger" heading in the Project Explorer, you can make the corresponding setting.

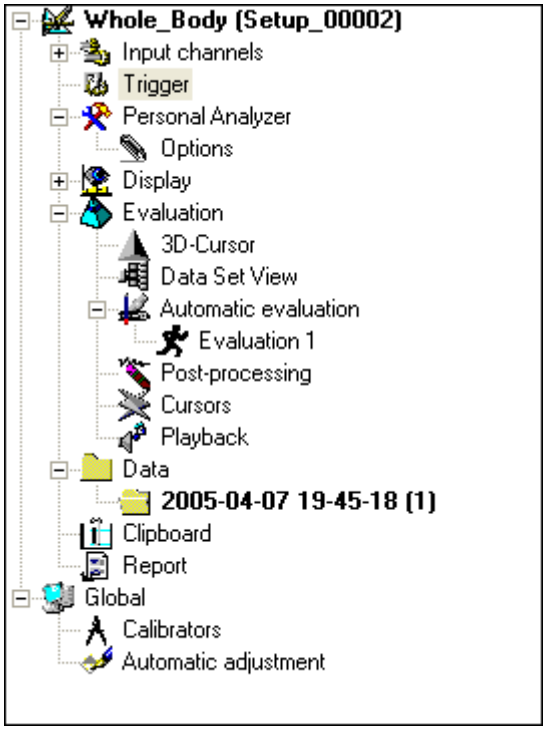

Fig. 210: Calling the trigger dialog

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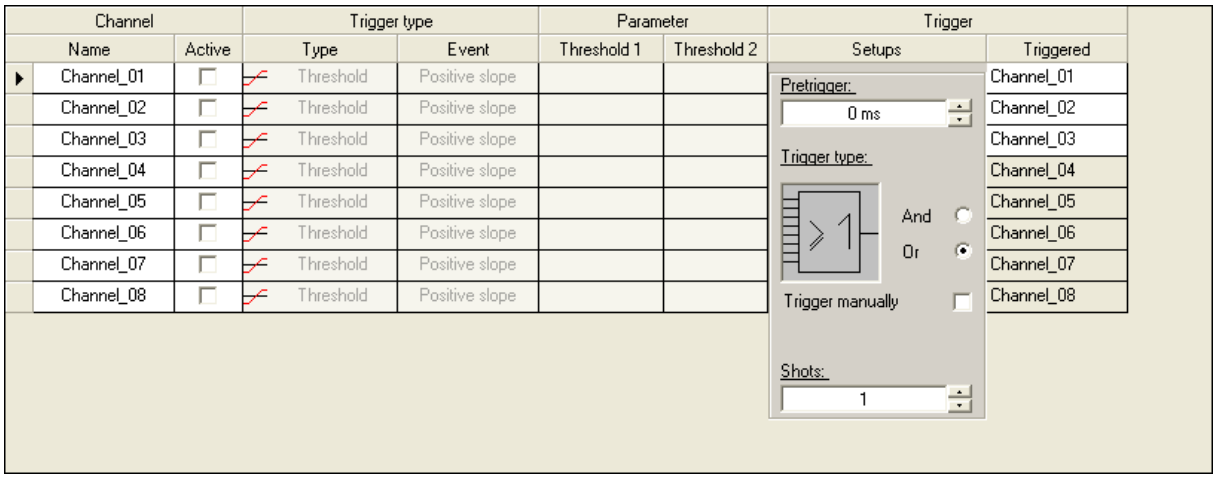

Fig. 211: Setting the trigger

Activate the option button "Manual trigger". No further settings need be performed in this dialog.

Now, when you prepare and start a measurement, an additional icon appears in the main window's toolbar next to the icon for preparing the measurement. Using this button, you can release the trigger and thus start measurement. This gives you the ability, for example, to carry out the measurement under a variety of operating conditions, in order to be able to see their effects on the data later on.

Below are shown some possible measurement results:

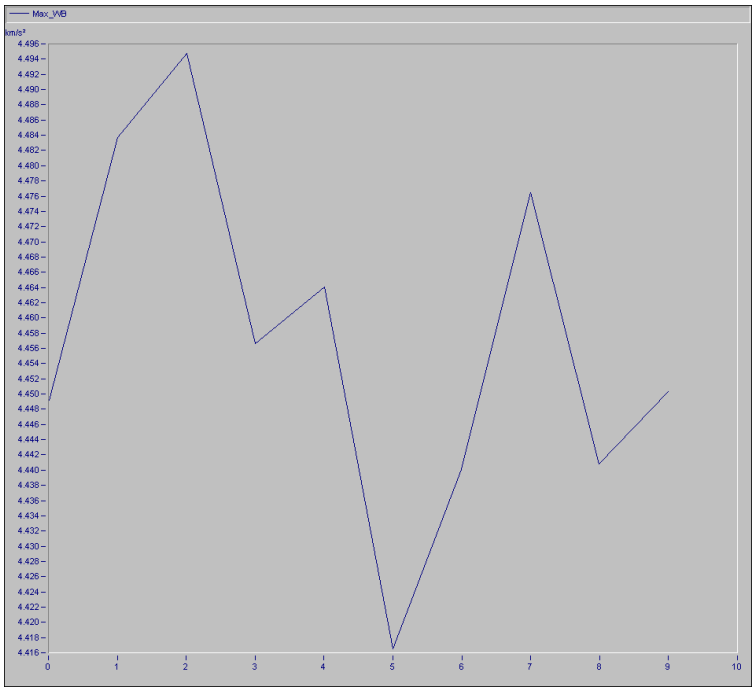

Fig. 212: Maximum values of whole-body vibration in three spatial dimensions for 10 consecutive measurements

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Mean_WB	=	4.457E+03 m/s²
Var_WB	=	5.228E -03

Fig. 213: Mean values and variation coefficients for the whole-body vibration

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25 The Pass-by Analyzer

imc WAVE's Pass-by Analyzer was designed to carry out measurements of noise from passing vehicles in accordance with ISO 362. Care was taken to ensure that both measurement and analysis could be performed completely by imc WAVE, so that no additional programs are necessary for computing or displaying the results of a pass-by experiment.

25.1 What is a pass-by test?

Pass-by tests are used by the automotive industry to learn how much noise their vehicles produce while driving past. The measurement setup represented by the diagram below, consisting of microphones, light barriers and the driving path, is stipulated by the standard ISO 362.

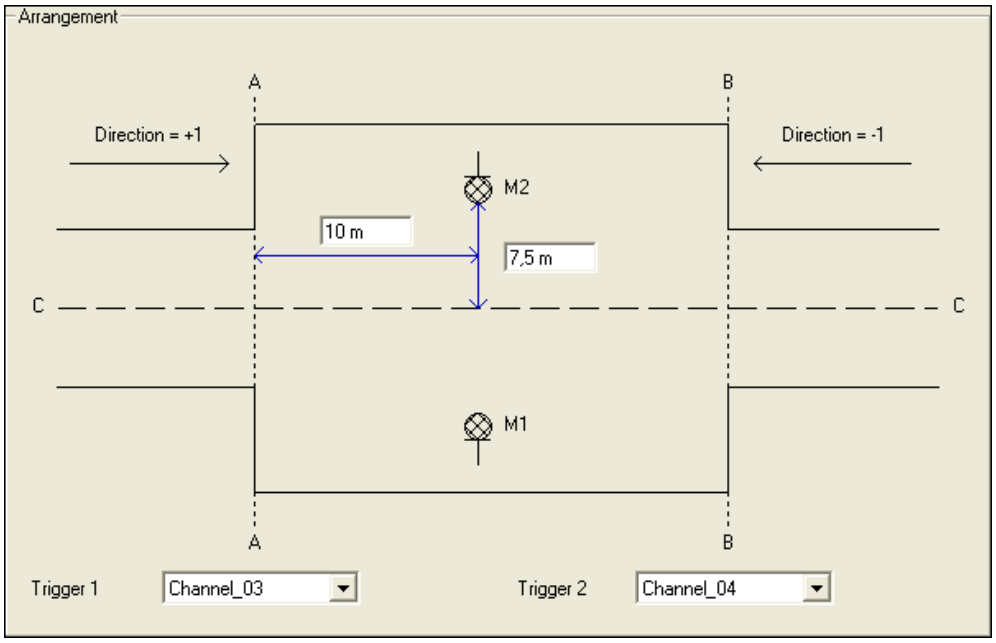

Fig. 214: Measurement setup for a pass-by test as per ISO 362

The vehicle passes the microphones M1 and M2 along the dotted line. The measurement starts when the vehicle passes the line AA and ends when it passes BB. The duration of data acquisition thus depends on the distance AA – BB and the vehicle's speed. In this experimental setup, measurements can be carried out for passes in both directions if the data are correctly assigned to the respective side of the vehicle. The overall result for the pass-by noise is the highest noise level reached in the course of the measurement. However, this level is only valid if it is measured in several consecutive runs to within a certain tolerance.

25.2 How to configure the standard microphone channels

The two microphone channels M1 and M2 are imc WAVE's default channels for the pass-by test. Along with these default channels, additional

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measurement channels can be defined. For details, refer to the next chapter.

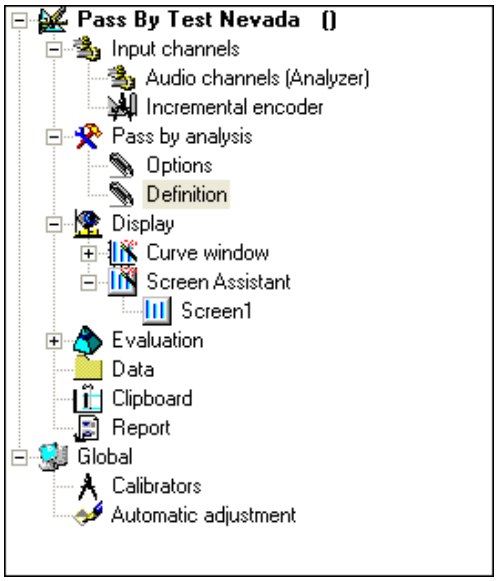

Fig. 215: Project Explorer with Pass-by Analyzer

As it is with all other analyzers, once the input channels have been configured the many settings for the Pass-by Analyzer itself can be made. To begin doing this, double-click on the Pass-by Analyzer's entry in the Project Explorer.

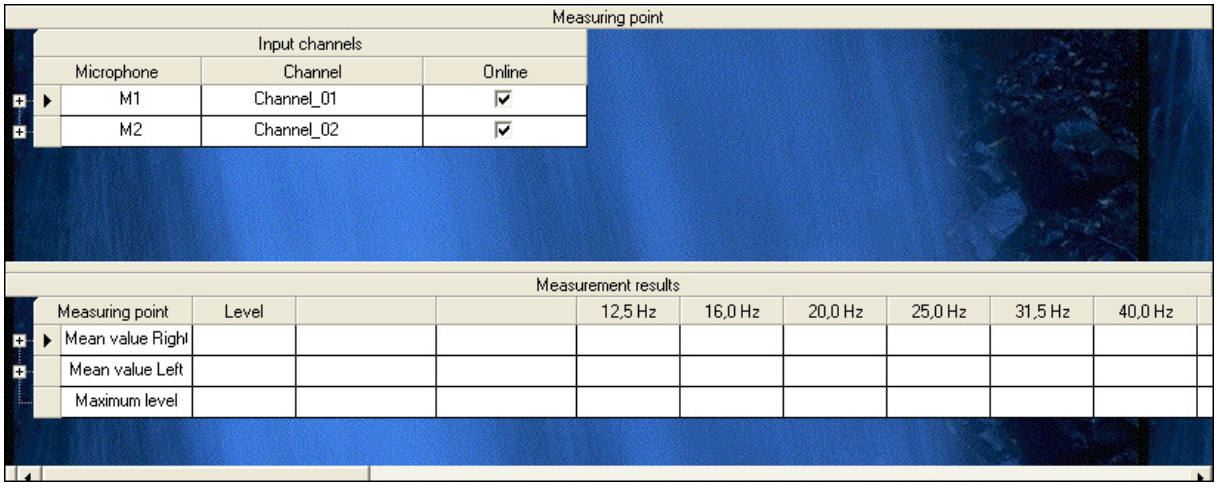

Fig. 216: Configuration and results table of the Pass-by Analyzer

The Pass-by Analyzer's dialog displays two tables; one for the input channels and one for the measurement results.

In the input channel table, you can see the two default microphones for measuring the noise from each side as the vehicle passes. In the table's second column, you must assign an input channel to each microphone. To do this, select a channel from the pop-down list in the second column.

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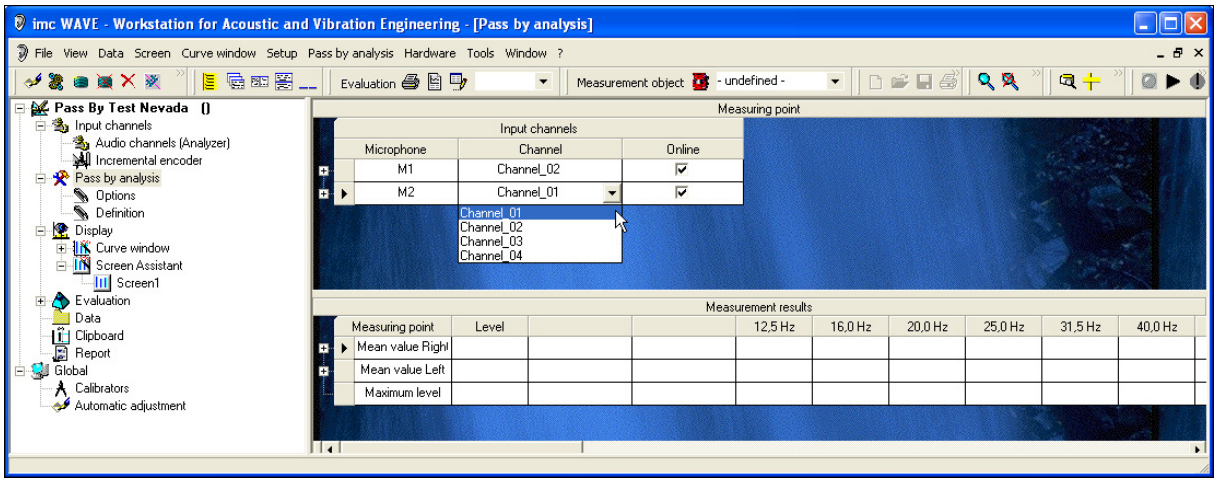

Fig. 217: Assigning a microphone to an input channel

You can also choose whether to calculate the octave or 1/3-octave spectra online or offline. For an online calculation, activate the option button "Online" for the desired signal. Online calculation is absolutely necessary for the two microphone signals, since the 1/3-octave spectra are needed for computing the measurement results directly after the pass-by run.

Each input channel in the Pass-by Analyzer has four different output channels:

1. Time signal
2. 1/3-octave spectrum
3. Octave spectrum
4. Sound pressure level

You can set for each of these channels separately whether or not to save it at the end of the measurement. It's also possible to edit the output channel's name.

To make the settings, begin by clicking on the "+" symbol in front of the desired input channel's row in the table.

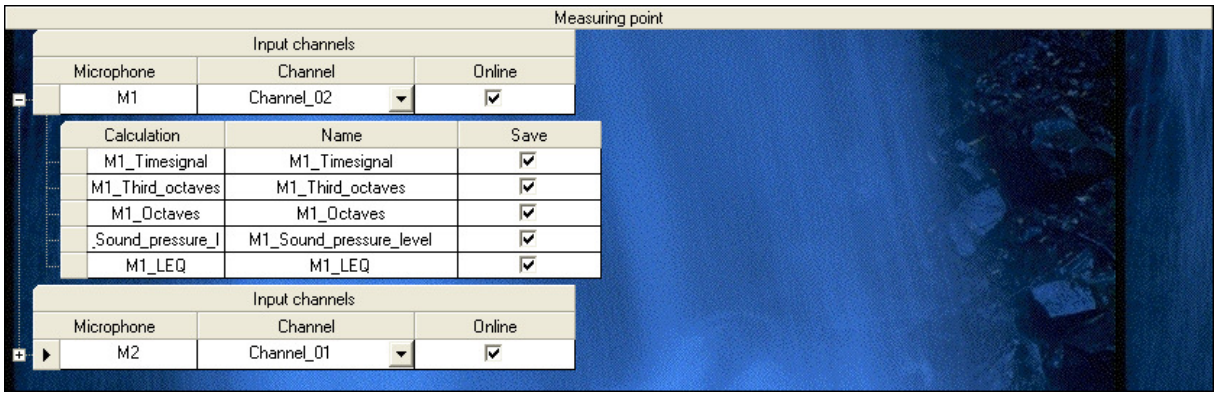

Fig. 218: Setting output channels in the Pass-by Analyzer

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This opens a subordinate table in which you can enter a name for the output channel under the heading "Name", and you can set whether the channel is to be saved by means of the option button under the header "Save".

To copy all of a channel's settings to other channels, select an input channel and access the context menu item "Copy channel settings".

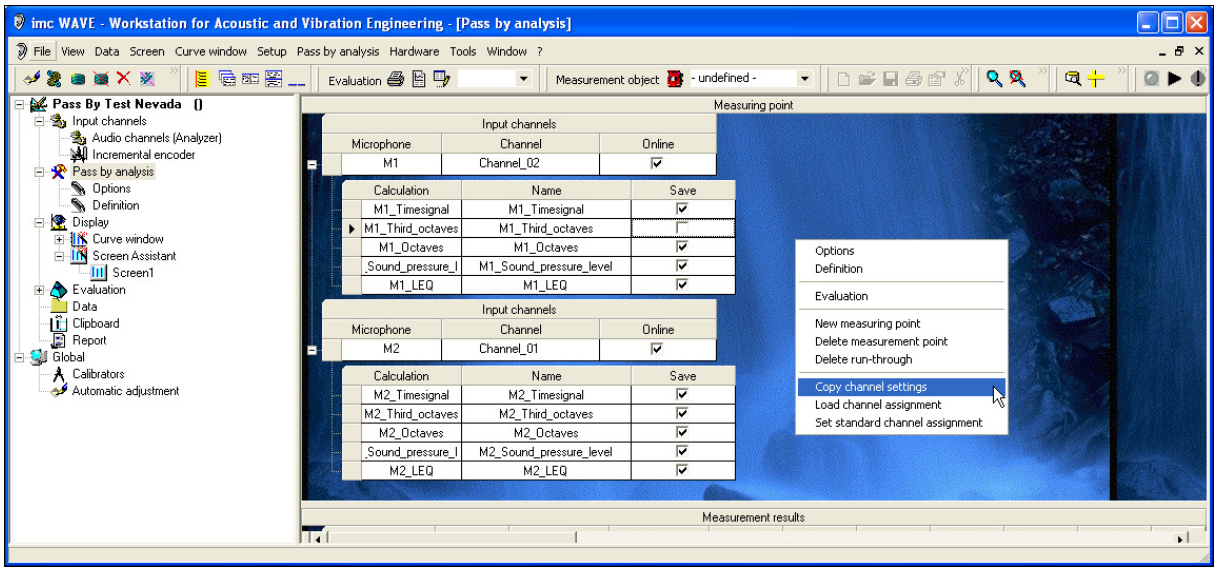

Fig. 219: Copying channel settings

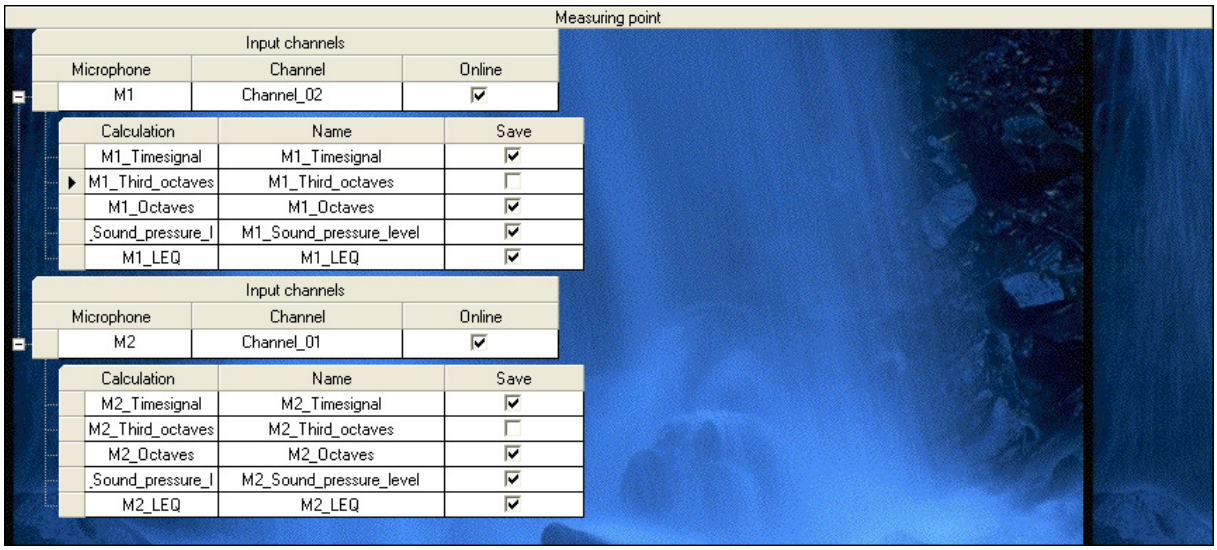

Fig. 220: Channel settings after copying

In case you often handle measurement assignments which are similar to each other, there is a simple way to assign the measurement system's input channels to the Analyzer's input channels: you can define and save a default channel assignment. For example, suppose you always assign the

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left microphone to Channel 2 and the right microphone to Channel 4, you could define this channel assignment scheme as the default and save it. To do this, simply select the item "Set default channel assignment" in the menu "Pass-by analysis". If you create a new project and wish to work with this default channel assignment scheme, then select the item "Load channel assignment" in the "Pass-by analysis" menu. In this way you will restore the last saved channel assignment scheme.

Now that the amount of input and output channels has been set, as well as which output channels are to be saved; we could proceed with starting a measurement. However, there are a number of optional parameters which can be used to modify the measurement in a variety of ways.

25.3 Optional parameters in pass-by analysis

Besides the standard specifications for pass-by analyses, there are additional parameters which are available for adapting the Analyzer to specific applications.

25.3.1 Measurement setups and triggers

As indicated above, the measurement takes place between the lines AA and BB. The better to picture how things are done, imc WAVE presents a schematic sketch of the measurement setup. This sketch is available at any time via the item "Definition" in the "Pass-by analysis" menu.

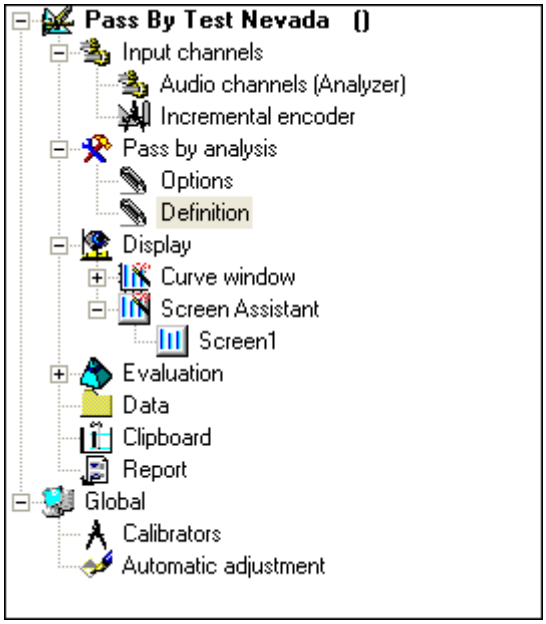

Fig. 221: Another way to access the schematic sketch of the setup

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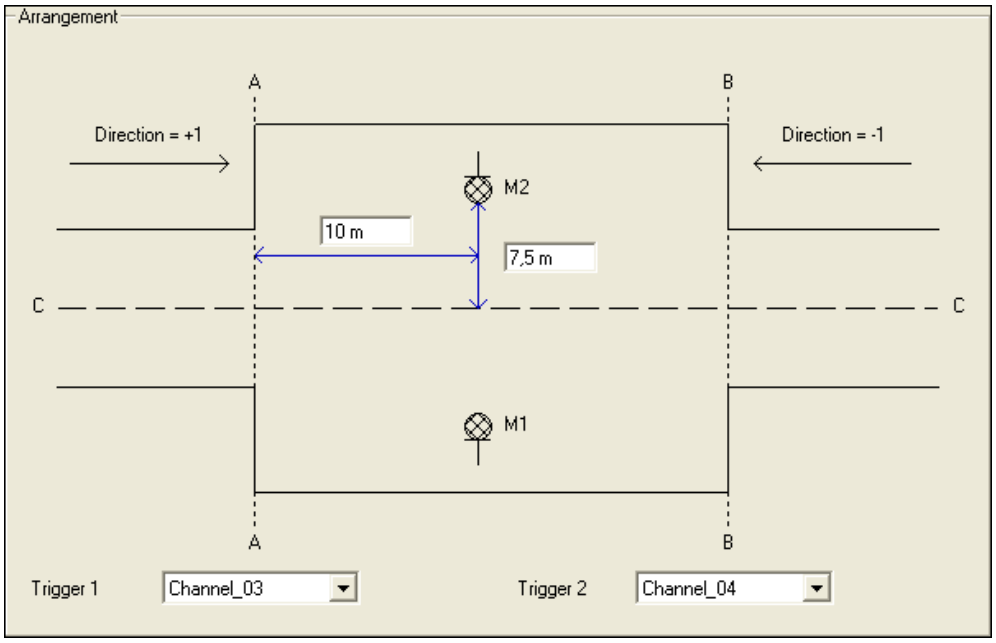

Fig. 222: Setup sketch

The sketch shows the different distances, lines of vehicle passage and of noise proliferation involved, and indicates the respective factors for the two directions of vehicle passage. There is also a list box at each of the lines AA and BB for setting which of your measurement device's channels starts measurement of the current run and which one stops it. The sensor types connected to these channels can take a variety of forms. For instance, if you are using light barriers, the signals can be connected directly to a digital input channel, which you could then define as Trigger 1 signifying crossing the line AA. Likewise, you could define Trigger 2 as crossing the line BB.

Now, once your vehicle crosses the line AA and thus the light barrier 1, the measurement is started automatically, and ends when the vehicle crosses the line BB and passes the associated light barrier.

The microphone positions as well as the distances between the trigger lines can be freely specified in this dialog, towards the end of making them adaptable to a variety of applications.

25.3.2 Options

The Pass-by Analyzer comes with a number of settings options, arranged in the following loose categories.

- Display
  Defining the calculation of the (1/3-) octave spectra

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- Vehicle
  Categorizes the vehicle as per ISO 362

- Left light barrier
  Parameters for the light barrier (Line AA)

- Right light barrier
  Parameters for the light barrier (Line BB)

- Environment
  Sets environmental conditions prevalent during measurement

- Criteria
  Sets conditions for automatically stopping the overall measurement

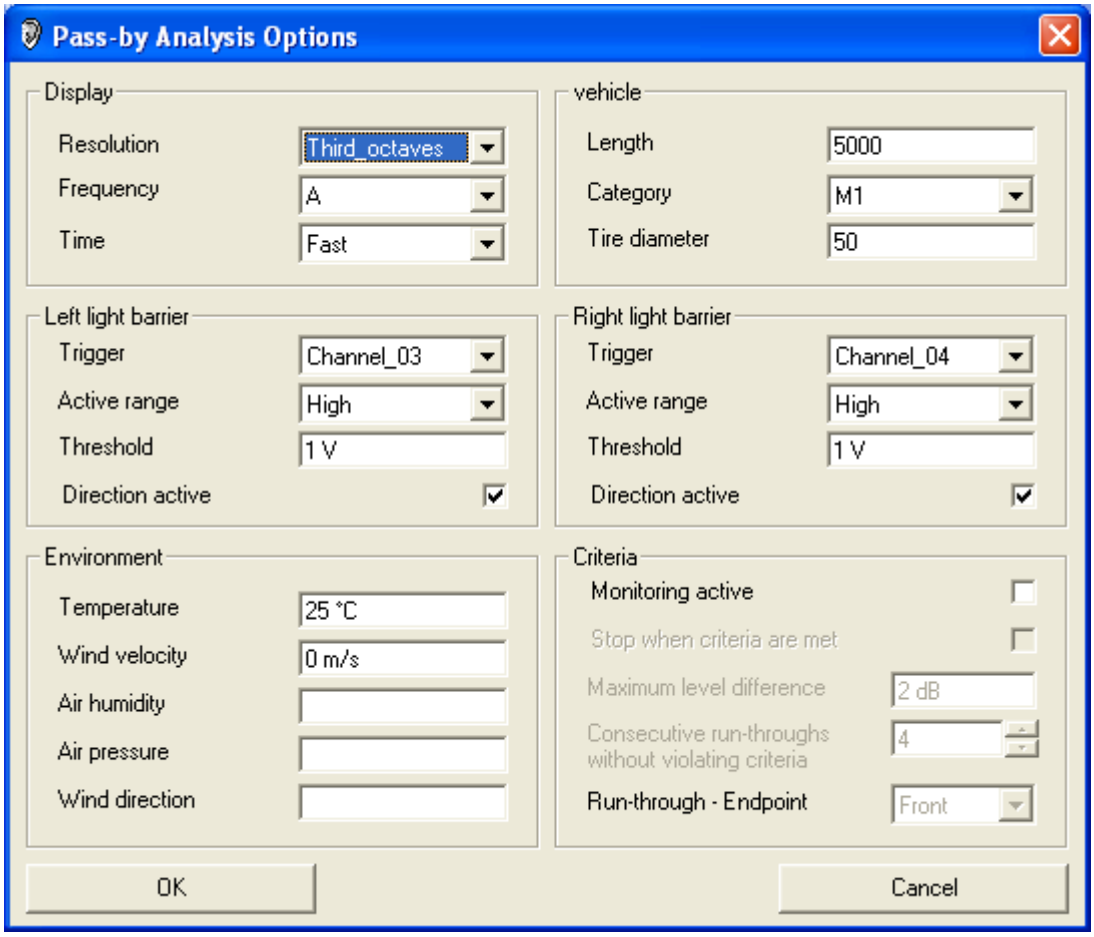

Fig. 223: Optional parameter settings for the pass-by test

Display

To suit either your objectives or the frequency resolution, you can choose whether you wish to carry out the measurement with either octave or 1/3-octave filtering. You can also select which filter to use for the frequency

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weighting (lin, A, B, C, D) and which time weighting to use for the calculation (Fast 125 ms, Slow 1 s).

Vehicle
Categorization of the vehicle adheres to ISO 362. Please refer to this standard for details.

Light barrier left / right
The left and right light barriers are used to trigger the start and stop of data acquisition for a pass-by test. Here, again, you have the opportunity to set which input channel to connect to which light barrier. You can also choose whether to start the measurement in Low-active or High-active mode, reference to a threshold value you supply (LOW-active: the measurement starts if the signal is below the threshold, High-active: the measurement starts if the signal is above the threshold).

Using the setting "Direction active", you can exempt your vehicle from testing in certain directions of travel. For instance, if there are physical impediments preventing your test stretch from being passed through from right to left (direction "–1"), then only activate the left light barrier.

If both directions are activated, both directions of vehicle passage are possible, though not absolutely necessary. imc WAVE always recognizes from which side the passage started and always assigns the measurement results to the corresponding side of the vehicle, so that correctly assigned results are ensured even for bi-directional pass-by testing.

For single-directional testing, the vehicle must not return by crossing through the light barriers, since a new measurement would otherwise be started, which would distort the overall test results.

Settings
Under this item in the dialog, you can set the maximum duration of a run-through, stated in seconds. After elapse of this amount of time, data acquisition is stopped unless the ‘undefined’ time was specified. This provides the ability to start the measurement either manually or by means of the light barrier, to allow the defined amount of time to elapse and then to stop the measurement without intervening. This kind of measurement is used, for instance, in the USA for measuring truck noise, or can be used to obtain preliminary results without very much trouble.

Environment
The environmental data are a record of the prevalent conditions affecting the measurement. They can be entered automatically in a measurement report upon completion of the measurement.

The environmental data include:

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1. Temperature
2. Wind velocity
3. Humidity
4. Air pressure
5. Wind direction

Criteria
The optional parameters appearing under the heading "Criteria" enable the automatic stopping of the pass-by tests upon fulfillment of user-defined conditions. This ensures that only the necessary amount of measurements is performed.

ISO 362 stipulates a set number of consecutive pass-by runs at a level, which must not change by more than x dB between successive runs. Once this amount of runs has been reached, the measurement can be stopped. You can set the following parameters:

1. Monitoring active
   This option button lets you toggle the monitoring on or off.

2. Stop when criteria are met
   If criteria monitoring is switched to active, you can use this control to choose whether the measurement is automatically stopped when the criteria are met of whether the measurement should continue until stopped manually.

3. Maximum level difference
   Definition of the maximum permitted difference between the levels of separate measurements

4. Consecutive run-throughs without violating criteria
   Defines the amount of measurement runs necessary for fulfilling the criteria

5. Run-through endpoint
   Determines where the point is at which the measurement ends;
   Front = arrival of the front of the vehicle triggers the light barrier
   Rear = the light barrier is triggered only once the vehicle has passed it completely

25.4 How to configure additional channels

Along with the default channels (microphones to the right and left of the driving path), it is possible to record other signals synchronously.

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You can select these signals either from the pool of extra channels und as additional analyzer channels. How to select and activate additional channels is described in a separate chapter of this documentation. However, the channels can be activated simply by double-clicking on the entry under the heading "Input channels" n the Project Explorer to open the dialog for activating channels.

This chapter will focus more closely on the additional Analyzer channels. To activate such a channel, right-click the mouse over the Pass-by analyzer's to call the context menu. There, select the item "New measuring point", or select the same item in the main window's "Pass-by analysis" menu.

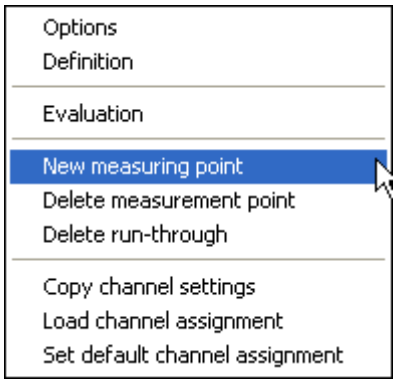

Fig. 224: Creating a new measurement point

Once the new point has been created, you are prompted to enter a name for it. When you're done, the table of input channels will appear as follows:

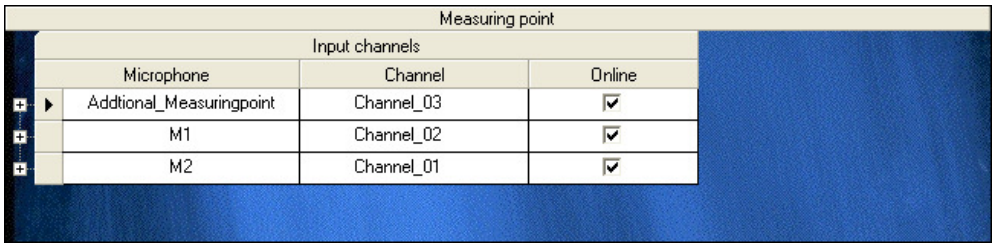

Fig. 225: New measuring point in the table of input channels

You can now configure this measuring point, just like can be done with the two default measuring points. You can rename the input channel, choose whether to do the calculations online or offline, assign a measurement channel, name the output channels and activate / deactivate data saving.

A measuring point can also be deleted from a project. To do this, select the item "Delete measurement point" in either the analyzer's menu in the main window or in the context menu. The measuring point will then be deleted from the input channel and measurement result tables. Note, however, that the associated measured data will be deleted along with the measuring points and will thus no longer be displayed.

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25.5 How to carry out a measurement

Once the measurement has been configured, you can proceed with actual run-throughs and the acquisition of their data.

Before the tests can be run, the necessary infrastructure must be provided. This includes at least two light barriers and two microphones, which must each be connected with one of the measurement system's input channels. Please refer to the operating instructions of your measurement system to learn about your connection options.

Once the necessary connections have been made, you can initialize measurement by pressing the button , and start measurement using the button .

The measurement system is then armed and waiting for a run-through to proceed. When the light barriers are triggered, data acquisition begins and the output channels (sound pressure, octave or 1/3-octave spectrum) are calculated online (if applicable). You can view the accumulating data in a screen. Toward that end, create a screen which displays the necessary measured data (on this topic, see the chapter on creating curve windows and screens).

Upon the completion of each run-through, the data acquired are transferred to the table of results. In the process, a new line is added to the results table under either the default input channels or the extra channels, into which the results are entered.

Each row presents the following parameters' values:

1. Run-through
   Number of the run-through being performed

2. Level
   Sum level characteristic of the run-through; in ISO 362, the maximum level reached during the run

3. Direction
   Refers to the direction in which the vehicle passes
   L->R from left to right
   R->L from right to left

4. Active
   If a run-through was valid, an Active-flag is set. It indicates that the current measurement agreed with the last measurement(s) to within

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a defined tolerance.

5. (1/3 -) octave spectra
   The subsequent table columns display the values of the 1/3- or octave spectra, depending on the setting you mad in the Options dialog.

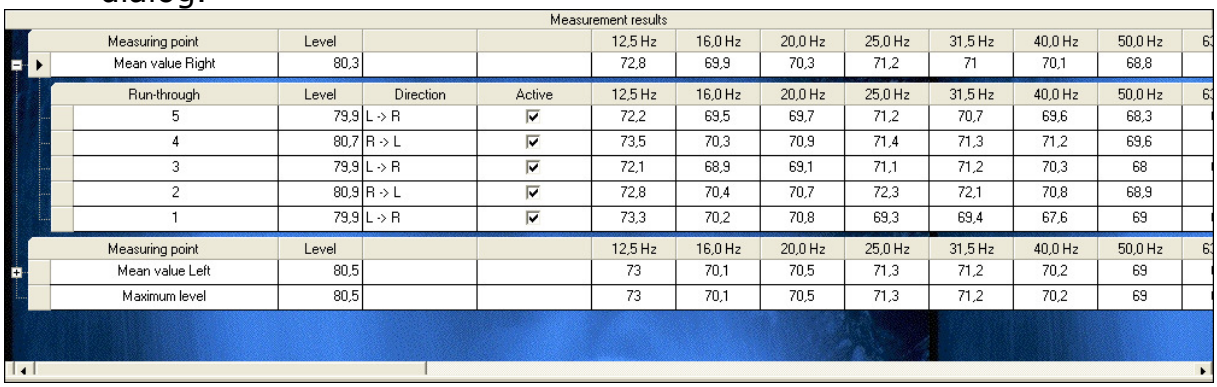

Fig. 226: Table of measurement results after some runs of the test

An input channel's master row in the table displays the currently calculated mean level value and the mean spectrum value at each frequency.

If you have activated monitoring of the criteria, imc WAVE automatically carries out a check of the criteria at the end of every run. If you activated the option button "Stop when criteria are met", data acquisition is automatically stopped when the criteria are met.

If a certain run-through should be omitted from the evaluation, due to external disturbance for instance, you can delete it by selecting the corresponding row in the results table and using the menu item "Pass-by Analysis / Delete run-through".

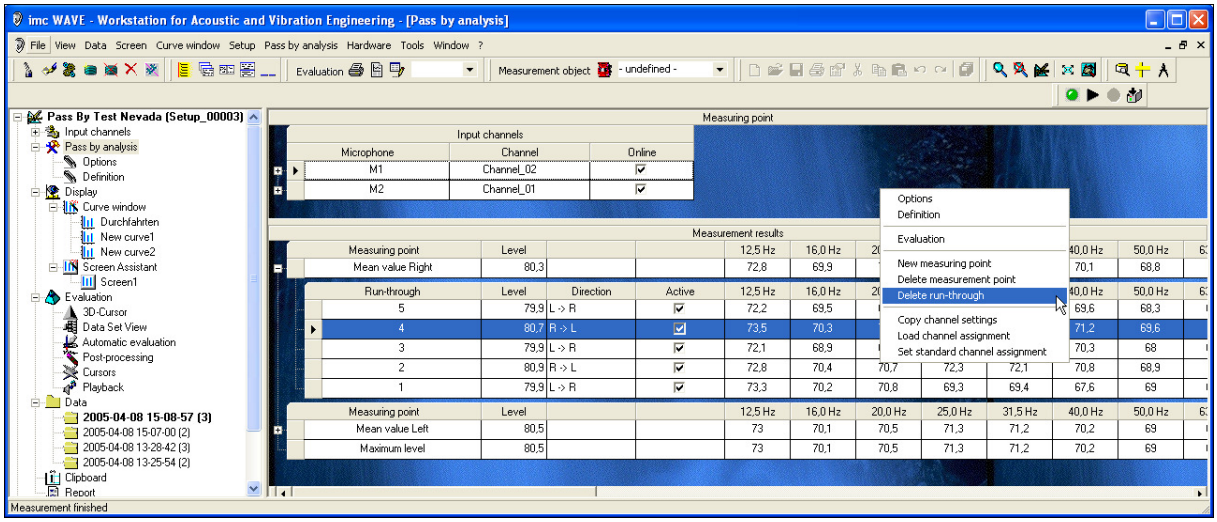

Fig. 227: Deleting a run-through

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Evaluation is carried out after each run-through, so that you can view the results from each one. If you wish to restart the evaluation manually after the measurement has been completed, perhaps because you have deleted faulty run-throughs or have changed the activation status of certain run-throughs, simply select the menu item "Pass-by Analysis/ Evaluation". Then the evaluation is repeated fully and its results entered into the table.

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26 The Spectrum Analyzer

Spectrum analysis is a widespread pursuit which, over the course of the last 40 years, has introduced a number of different calculated quantities of varying applicability. In the wake of the progress of PC's, certain algorithms previously impracticable due to their complexity have become feasible.

Spectrum analysis generally refers to the transformation of a time-domain signal to a complex variable domain reflecting the time-domain signal's composition. Probably the most familiar and widespread algorithm for spectrum analysis is Fourier transformation. But there are many other algorithms which enable representation of the signal in the complex variable domain. Among other ways, these algorithms can be distinguished by whether they completely map the signal into the complex variable domain or only partially, so that unique reverse transformation back to the time domain is no longer possible. This latter class of algorithms includes the 1/3-octave and octave filter banks, which by merging frequency ranges and by averaging RMS-values fail to provide phase data, and thus prevent reconstruction of the time-domain signal. However, these algorithms have the advantage over FFT-transformation of offering substantial data compression.

26.1 What calculated quantities are available?

The Spectrum Analyzer offers the following output quantities:

FFT – Fourier spectrum of input signal

Filter banks

- 1/3-octaves – results returned by a filter bank of 1/3-octave filters
- Octaves – results returned by a filter bank of octave filters
- 1/12-octaves – results from a filter bank of 1/12-octave filters
- 1/24-octaves – results from a filter bank of 1/24-octave filters

RMS – plot of the input signal's RMS-value

LEQ – plot of the input signal's energetic mean value

26.2 How to configure the Spectrum Analyzer

Like all other analyzers, the Spectrum Analyzer transforms input quantities to output quantities. The input quantities are linked to the

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measurement system's channels. The output quantities represent the Analyzer's output signals.

To open the Spectrum Analyzer's configuration dialog, double-click on the entry "Spectrum Analyzer" in the Project Explorer.

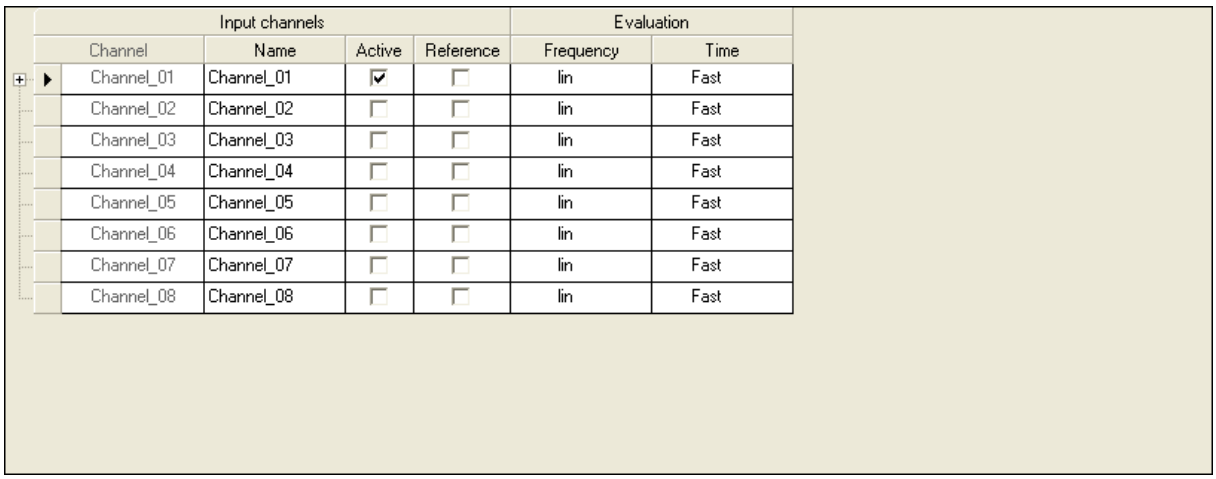

Fig. 228: Spectrum Analyzer configuration dialog

The following settings are available for the Spectrum Analyzer's input channels:

1. Name
   Here you can edit the input channel's name.

2. Active
   Changing the status of this option button lets you toggle between activating and deactivating the respective input channel in the Analyzer.

3. Reference
   Activating this option button sets the respective channel as the reference channel for calculating the transfer functions. Then all transfer functions are calculated in reference to this channel.

4. Evaluation – Frequency
   Select the frequency weighting desired from the pop-down list. The frequency weighting is only carried out for the calculated spectra and sum values. The time signal remains unaffected.

5. Evaluation – Time
   Select the time weighting desired from the pop-down list. The time weighting is only carried out for the calculated spectra and sum values. The time-domain signal remains unaffected.

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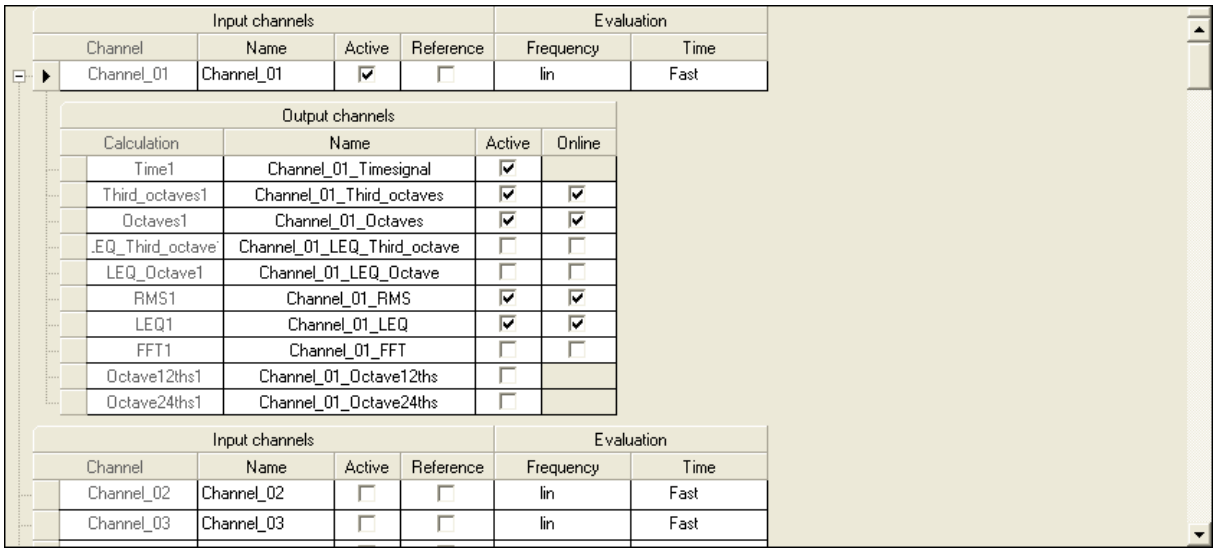

Input channels				Evaluation	
Channel	Name	Active	Reference	Frequency	Time
Channel_01	Channel_01	☑	☐	lin	Fast

Output channels			
Calculation	Name	Active	Online
Time1	Channel_01_Timesignal	☑	
Third_octaves1	Channel_01_Third_octaves	☑	☑
Octaves1	Channel_01_Octaves	☑	☑
.EQ_Third_octave'	Channel_01_LEQ_Third_octave	☐	☐
LEQ_Octave1	Channel_01_LEQ_Octave	☐	☐
RMS1	Channel_01_RMS	☑	☑
LEQ1	Channel_01_LEQ	☑	☑
FFT1	Channel_01_FFT	☐	☐
Octave12ths1	Channel_01_Octave12ths	☐	
Octave24ths1	Channel_01_Octave24ths	☐	

Input channels				Evaluation	
Channel	Name	Active	Reference	Frequency	Time
Channel_02	Channel_02	☐	☐	lin	Fast
Channel_03	Channel_03	☐	☐	lin	Fast

Fig. 229: The Spectrum Analyzer's output signals

For each physical input channel, the following output channels can be computed:

1. Time
   Here, only the time-domain data necessary for calculating the spectral data are stored.

2. 1/3-octaves
   Computation of the input signal's 1/3-octave spectrum

3. Octaves
   Computation of the input signal's octave spectrum

4. RMS
   Computation of the input signal's RMS value

5. LEQ
   Calculation of the true-energy averaged sound level, in dependence upon the frequency- and time-weighting set

6. FFT
   Calculation of the Fourier spectrum according to the optional parameter values set

7. Octave 12^{ths}
   Computation of the input signal's 1/12-octave spectrum

8. Octave 24^{ths}
   Computation of the input signal's 1/24-octave spectrum

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The following additional output signals can be calculated for the input channels which weren't designated the reference channel:

1. 1/3-octave transfer function
2. octave transfer function
3. 1/12-octave transfer function
4. 1/24-octave transfer function

The transfer functions in the 1/n octave spectra are formed by simply dividing the magnitudes of the individual spectral lines, since all phase information was already lost when the octave or 1/3-octaves were calculated.

The various output signals each have a different amount of parameters to set:

1. **Name**
   Name of the output signal
2. **Active**
   Activation of the output signal for calculation and later for storage of the data
3. **Online**
   Here you can select whether to calculate the output signal online or offline.

Once you have configured the input and output channels, we can turn to the topic of setting the optional parameters.

26.3 Optional parameters for the Spectrum Analyzer

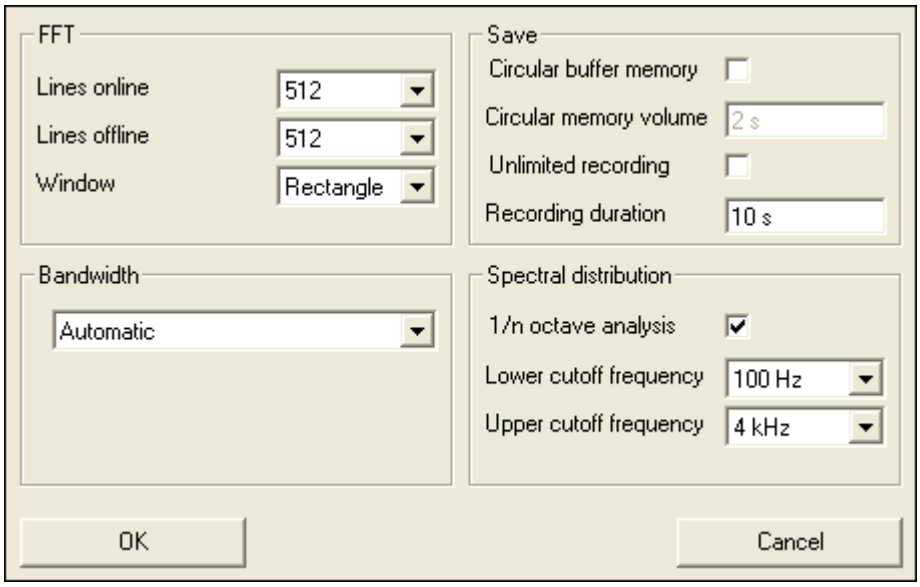

Fig. 230: Optional Spectrum Analyzer settings

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The optional settings are arranged in the following groups:

- FFT
  Settings for configuring the FFT

- Bandwidth
  Settings for defining the maximum signal bandwidth of the physical input channels

- Save
  Definition of the acquisition time and of the circular buffer memory

- Spectral distribution
  Activation and configuration of the 1/n-octave filter for n>=12

These optional parameter settings enable you to configure the Spectrum Analyzer according to your own wishes.

26.3.1 FFT parameter settings

For configuring the FFT (Fast Fourier Transform), the following parameters are available

- Online-Points
  Here you can set the amount of points from which the Online-FFT is calculated. The online-FFT's line count is less than that of the offline FFT and refers to the range from 0 Hz to one-half of the sampling frequency. Together with the sampling frequency, the point count determines the spectrum's resolution. At this time, only powers of 2 are accepted.

- Lines Offline
  The computation of the offline-FFT, which takes place after the measurement, is performed using the amount of lines specified here. This line count can be greater than the online-FFT's line count.

- Window
  The window functions are multiplied with the time-domain signal. This enables the user to choose between good frequency resolution but possibly bad amplitude fidelity (rectangular window), and high amplitude fidelity but bad frequency resolution (flat top). The following window functions are available:

  Rectangle
  Hamming
  Hanning
  Blackman
  Blackman Harris

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Flat Top

These window functions each have different properties, for details of which please refer to the pertinent literature.

26.4 How to carry out a measurement with the Spectrum Analyzer

Once we have configured a measurement, we can carry out measurements.
Before conducting a measurement, the corresponding measurement setup must be made available. Connect the appropriate sensors to the measurement device and connect the measurement device to the computer. For assistance in this, refer to the included imc CRONOS PL user's manual.

Once the necessary connections have been made, you can initialize measurement by pressing the button , and start measurement using the button . If you haven't defined any trigger, the measurement will start now. If you have defined a trigger, data acquisition will only begin when the trigger is released. The accumulating data can be viewed in a screen. Toward that end, create a screen which displays the necessary measured data (on this topic, see the chapter on creating curve windows and screens).

Upon the measurement's conclusion, the data can be saved to the disk automatically (on this topic, see the chapter "Data" on the available settings options).

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27 Work Station Noise Analyzer

Even relatively low sound pressure levels affect our ability to concentrate and our performance at the workplace. This causes an increase in mistakes and accidents. At high levels of sound pressure, there is a risk of hearing loss. A number of regulations exist to limit workplace noise levels. These oblige companies to measure the existing noise and to take steps to reduce levels if they are too high.
The Workplace Noise Analyzer is designed to support such efforts. It provides a user-friendly configuration interface for measuring workplace noise.

27.1 What calculated quantities are available?

For the purpose of measuring workplace noise, the following measurement quantities can be used:

- Time signal
  Time plot of the input signal

- 1/3-octave spectrum
  power average of a bank of 1/3-octave filters' output signal

- Octave spectrum
  power average of a bank of octave filters' output signal

- LEQ
  Time plot of the input signal's power average

27.2 How to configure the Workplace Noise Analyzer

Like all other analyzers, the Workplace Noise Analyzer transforms input quantities to output quantities. The input quantities are linked to the measurement system's channels. The output quantities represent the Analyzer's output signals.

To open the Spectrum Analyzer's configuration dialog, double-click on the entry "Workplace Noise Analyzer" in the Project Explorer.

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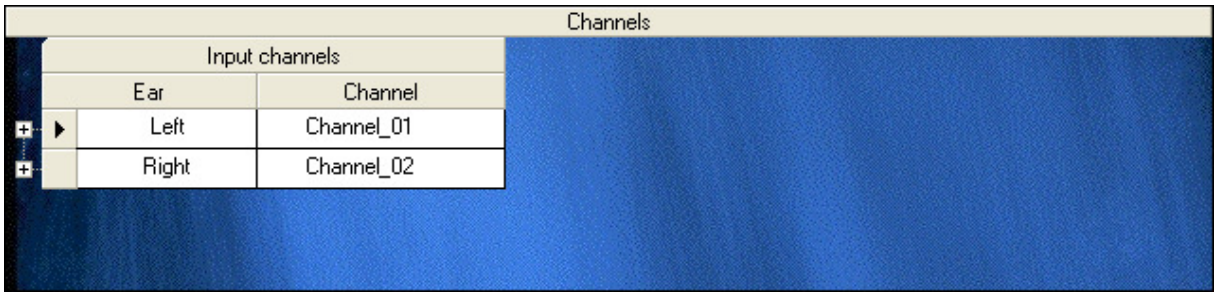

Fig. 231: Workplace Noise Analyzer configuration dialog

The measurement of workplace noise is carried out on two channels. The configuration dialog has one control apiece for the left and the right ear. Under the heading "Channel", you can assign a physical input channel to each ear's microphone.

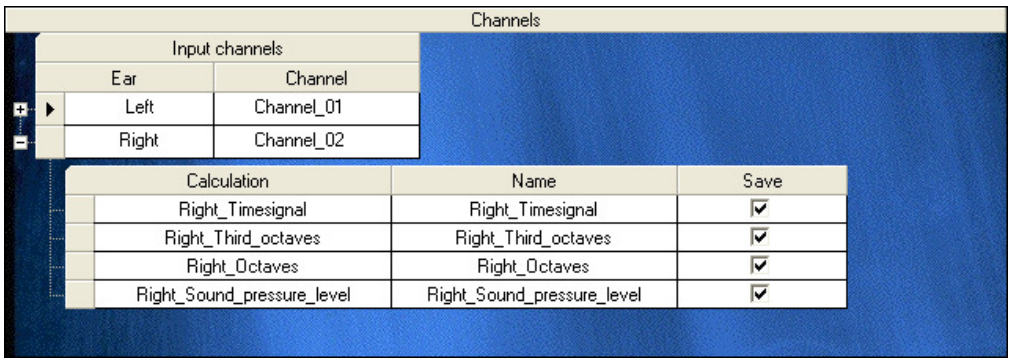

Fig. 232: Workplace Noise Analyzer output signals

For each physical input channel, the following output channels can be computed:

1. Time data
   Here, only the time-domain data necessary for calculating the spectral data are stored.

2. 1/3-octaves
   Computation of the input signal's octave spectrum's power average

3. Octaves
   Computation of the input signal's octave spectrum's power average

4. LEQ
   Computation of the input signal's power average

Each output signal type has its own number of possible parameter settings:

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- Name
  Name of the output signal

- Save
  Activates saving of output signal upon completing the measurement

The measurement's results are displayed in a table in the Analyzer dialog's lower portion.

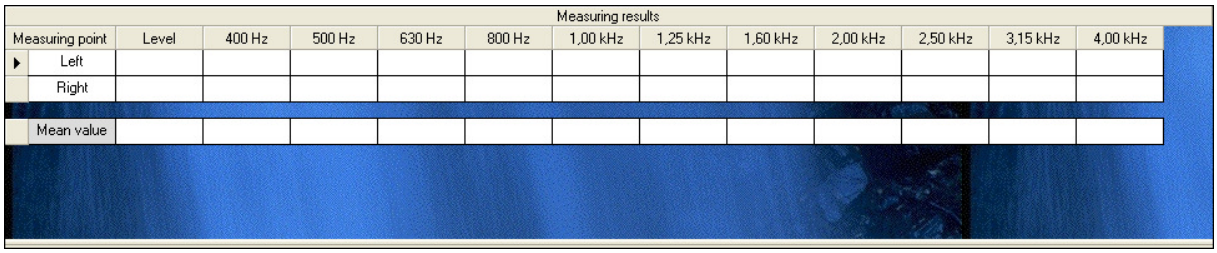

Fig. 233: Workplace Noise Analyzer results table

This table indicates the overall level and the resulting octave and 1/3-octave spectra for each ear. In addition, at the end of the measurement the mean of the two values is displayed below the table.

Once you have configured the input and output channels, we can turn to the issue of setting optional parameters.

27.3 Optional parameters for the Workplace Noise Analyzer

The following parameter settings are available.

- Frequencies
  Defines the resolution of the filter bank and of the frequency range

- Weighting
  Definition of the time and frequency weighting, as well as of the measurement duration

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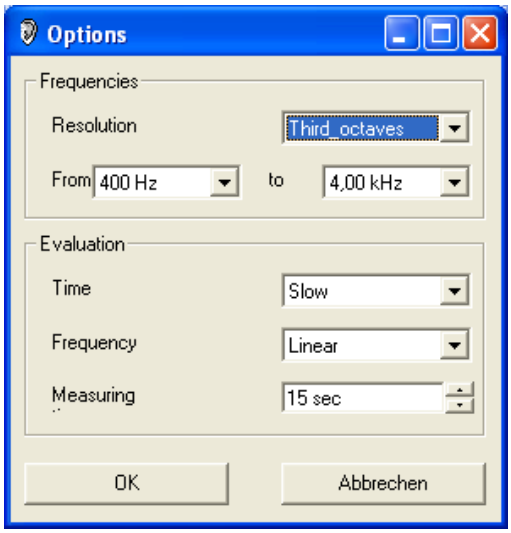

Fig. 234: Workplace Noise Analyzer options dialog

27.3.1 Frequencies

The control "Resolution" lets you toggle between the settings octaves and 1/3-octaves for the display in the results table. You can also set limits to the input range displayed using the two list boxes. However, even when the range is limited, all frequencies measured can still be displayed; but the formation of the mean value applies to only the limited range. To have all frequencies displayed, go to the Workplace Noise Analyzer's menu and make sure that the item "Only active frequencies" isn't check-marked.

27.3.2 Weighting

For the time weighting, you can choose between "Slow" and "Fast"; and for frequency weighting you can choose among "Linear", "A", "B", "C" and "D". To do this, simply click on the corresponding entry in the respective pop-down list box.

The other control, "Measuring duration", lets you set the duration of the noise measurement. Enter the value desired in terms of seconds.

27.4 Running a measurement with the Workplace Noise Analyzer

Once we have configured a measurement, we can carry out measurements.
Before conducting a measurement, the corresponding measurement setup must be made available. Connect the appropriate sensors to the measurement device and connect the measurement device to the computer. For assistance in this, refer to the included imc CRONOS PL user's manual.

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Once the necessary connections have been made, you can initialize measurement by pressing the button , and start measurement using the button . If you haven't defined any trigger, the measurement will start now. If you have defined a trigger, data acquisition will only begin when the trigger is released. The accumulating data can be viewed in a screen. Toward that end, create a screen which displays the necessary measured data (on this topic, see the chapter on creating curve windows and screens).

Upon the measurement's conclusion, the data can be saved to the disk automatically (on this topic, see the chapter "Data" on the available settings options).

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